2019

Northern Hardwood Silviculture: Preferences among Family Forest Owners in the Western Upper Peninsula of Michigan

Alexander C. Helman
Michigan Technological University, achelman@mtu.edu

NORTHERN HARDWOOD SILVICULTURE: PREFERENCES AMONG FAMILY FOREST OWNERS IN THE WESTERN UPPER PENINSULA OF MICHIGAN

By

Alexander C. Helman

A THESIS

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

In Forestry

MICHIGAN TECHNOLOGICAL UNIVERSITY

2019

This thesis has been approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE in Forestry.

School of Forest Resources and Environmental Science

Thesis Advisor:	*Dr. Matthew Kelly*
Committee Member:	*Dr. Audrey Mayer*
Committee Member:	*Dr. Mark Rouleau*
School Dean:	*Dr. Andrew Storer*

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Acknowledgements

I'd like to thank my advisor, Dr. Matt Kelly, as well as my committee members, Dr. Audrey Mayer and Dr. Mark Rouleau, for their support and input on my project over the course of my time at Michigan Tech. I'd also like to thank Dr. Yvette Dickinson for spearheading the NHSEED project and providing support regarding the silvicultural aspects of my study. Sara Hoy, Dr. Robert Froese, and Mike Smalligan provided helpful feedback on the survey booklet and other aspects of my research. Rodney Thompson, Mechelle Normand, and the entire staff at Michigan Tech's Print and Mail Services were extremely helpful in the arduous printing and mailing process that a mailed survey requires.

I'd also like to thank Dr. Andrew Storer for his assistance and encouragement in starting my path in forestry. Finally, I'm extremely grateful for the support of my partner, Ally, and my family and friends throughout my graduate career.

Abstract

In the northern hardwood forests of the Western Upper Peninsula of Michigan, single-tree selection is the most commonly used silvicultural system. This system provides both a sustained yield of timber and attempts to emulate the windfall disturbance regime that determines the uneven aged structure of northern hardwood forests. However, with concerns about tree species diversity loss and a lack of early successional forests, even-aged regeneration methods are likely to become an increasingly crucial tool in the toolbox for managing northern hardwood forests of the Lake States. The forests of the Western Upper Peninsula are comprised of a mosaic of ownerships, with nearly 40% of the forested land owned by family forest owners. This study assessed family forest owners experience with, perceptions of, and interest in three different silvicultural methods recently implemented as a part of a long-term silviculture study on Michigan Technological University's Ford Forest. A mailed survey with images and descriptions of clearcut, shelterwood, and single tree selection harvests was sent to family forest owners with at least 20 acres of forestland in the Western Upper Peninsula. The survey also included questions about landowners' use of their forestland, management experience, incentive-program enrollment, and demographics. The findings indicated that family forest owners who rank timber as important reason for owning forestland are the most likely to be accepting of all three methods. Respondents who use their land for hunting are also very likely to implement clearcut and shelterwood methods. Other findings include different preferences for management between absentee and non-absentee landowners. The results of this study suggest that targeting hunting groups and actively managing landowners may have a positive effect on the understanding and acceptance of silviculture among family forest owners.

1. Introduction

Family forest owners (FFOs) own roughly 36% of United States' forests (Butler, Hewes, et al., 2016). A large body of research exists that is dedicated to understanding the complex attitudes and behaviors of FFOs. Many of these studies focus on determining the various means in which landowners interface with some type of forest management. Using theories from economics, psychology, sociology, and other social sciences, researchers have investigated FFOs' actions and perceptions surrounding forest management activities such as biomass harvesting, commercial timber harvests, defensible space, forest health, and recreation (Collins, Darr, Wear, & Brown, 2008; Ferranto et al., 2013; Hunt, 2002; Lankford, 1994; Silver, Leahy, Weiskittel, Noblet, & Kittredge, 2015).

However, few studies have investigated FFOs' experiences, perceptions, and affiliations with silviculture in general, or with specific silvicultural prescriptions (Munsell & Germain, 2007). Although many studies have assessed what drives landowners to perform management activities such as commercial thinnings, biomass harvesting, and wildlife habitat improvement, few, if any, studies have determined the familiarity, experience, and interest that FFOs have regarding specific silvicultural prescriptions. Factors such as willingness to harvest and acceptability can help to inform managers and researchers about the viability of silvicultural methods on family forest land. In addition, concerns for reduced species diversity and resilience of northern hardwood forests in the Lake States have been raised by forest ecologists and the literature suggests more intensive methods that result in greater removals and larger canopy openings during harvest than common practices (Crow, Buckley, Nauertz, & Zasada, 2002; Hupperts, Dickinson, Webster, & Kern, 2018; Neuendorff, Nagel, Webster, & Janowiak, 2007; Schwartz, Nagel, & Webster, 2005). Little is known about the acceptance of silvicultural practices for managing northern hardwoods among FFOs.

This study addresses the acceptability and familiarity of three silvicultural methods applied throughout the northern hardwood forests of the Western Upper Peninsula (WUP) of Michigan - single tree selection, shelterwood, and clearcut.

Demographics, reported behaviors, and ownership characteristics will help to illuminate why certain methods are more popular with family forest owners than others, who implements them, and identify the various predictors for engaging in certain silvicultural activities. The following literature review provides the necessary background on current knowledge about FFO actions, common theories used to understand their behavior, and the gap in the literature that this study attempts to address.

2. Literature Review

2.1 A brief history of family forest owner research

Family forest owners have long been a topic of interest in forestry research in the United States and abroad (Thomas J. Straka, 2011). The first U.S. Forest Service sponsored survey of FFOs in the United States took place in 1978 (Birch, Lewis, & Kaiser, 1982). Some key findings from this first FFO study include the discovery that most FFOs lived near their land, a large percentage were retired, and that nearly half of the forestland accounted for in the survey had been acquired in the previous 30 years. Many of these early findings still hold true today. A second survey of the same nature took place in 1994 (Birch, 1996). A few notable findings from this study include the small percentage (5%) that have a written management plan control 34% of the forest land, and the recurring finding of a large percentage of landowners being retirees. More recently, there have been multiple iterations of the National Woodland Owner Survey (NWOS) and subsequent studies of FFOs (Butler, 2008; Butler, Hewes, et al., 2016; Butler & Leatherberry, 2004). These studies have laid the groundwork for the contemporary understanding of the major themes and areas of concern among FFOs in the United States.

In addition to studies in the United States, there is a strong legacy of FFO research in Finland (Hallikainen, Hypponen, Pernu, & Puoskari, 2010; Hujala, Pykalainen, & Tikkanen, 2007; Karppinen, 1998; Kuuluvainen, Karppinen, & Ovaskainen, 1996). Much like the studies performed in North America, these studies investigate various issues such as landowner objectives, professional advice, owner values, and FFOs' role in the supply of timber.

2.2 Theoretical frameworks to guide FFO research

The two main sociological theories that have been used to explain behavior among FFOs. The theory of planned behavior and its predecessor, the theory of reasoned action, attempt to understand and predict the influences of motivations on behavior (Madden, Ellen, & Ajzen, 1992). The other, starkly utilitarian model is the sociological rational choice theory (Hechter & Kanazawa, 1997). The following subsections provide a brief explanation of each theory and some examples of their use in understanding behavior among FFOs.

2.2.1 Theory of reasoned action and theory of planned behavior

This theory states that "intention is the immediate determinant of behavior" (Madden et al., 1992) and acts as the most important predictor for determining actions. This greatly depends on the correspondence between the intention that is measured and the behavior that is observed, as well as how stable the intention remains over time. The existence of a time window is important in this theory because when measuring intention, the nearer the time horizon, the more prediction of a behavior is more accurate. The behavioral intention is influenced by attitudes, subjective norms, and perceived behavioral control. An attitude reflects how an individual may feel regarding a behavior (positive or negative), the subjective norm is the perception an individual has regarding what they think their peers want them to do, and behavioral control is the possession of information and opportunities that relate to a given behavior. This theory posits that favorable attitudes and norms, as well as the belief of control over ones actions, leads an individual to carry out a given behavior. It also explains that attitudes are formed by beliefs, and they can connect behaviors with outcomes.

Young and Reichenbach (1987) used the theory of reasoned action as the basis in their study of Illinois FFOs. Using a telephone survey of 621 Illinois FFOs and multiple regression analysis the authors measured the appropriateness of attitudes and the subjective norms to predict landowner intentions. Regression was also used to determine the relationships between attitudes and beliefs and to evaluate the relationship between normative beliefs and the motivations to harvest timber. Only 22% of respondents

intended to harvest timber in the next 10 years. Forty five percent of respondents had negative intentions regarding timber harvesting. The strongest relationship was between the subjective norm and intention, meaning that landowners were greatly influenced by those they deemed important in their community. These results show similar phenomena that are comparable to the family networks that influence FFO management in the WUP (Lind-Riehl et al., 2015).

A 2015 study of FFOs in Finland used the theory of planned behavior and data from the Finnish landowner survey to explain decisions surrounding forest stand improvement (Karppinen & Berghäll, 2015). The authors found that the subjective norm was the most important explanatory factor in decision making, with attitudes playing a significant, but smaller role. The factors involved in establishing subjective norms amongst Finnish landowners included perceived attitudes and interests of forestry officials, local wood purchasers, and family members, where the forestry officials had the largest explanatory value. Attitudes towards profitability and growth had the greatest effects on decision making among the sample of FFOs. These findings show that while price is an important factor, norms play the largest role in explaining a given behavior.

2.2.2 Sociological rational choice theory

Rational choice theory assumes individuals make choices that satisfy their preferences and personal objectives, and thus are considered utility maximizers (Hechter & Kanazawa, 1997). The individual is assumed to use probabilities of events, available information, and costs and benefits when determining which option is likely to result in the greatest utility to the individual and is therefore preferred. This makes up the lower level of the rational choice model where the individual operates. At the upper level, social context, which includes norms and institutions, and new outcomes from actions, is the broader context for decision making. This places individual values and structural elements as equally important determinants of outcomes.

A criticism of rational choice theory is the reliance on imperfect or incomplete information, uncertainty, and cognitive limitations to making optimal decisions. However, it can be assumed that FFOs operate under a bounded rationality framework

(Aguilar, Cai, & Butler, 2017; Simon, 1972).This framework acknowledges that landowners have imperfect knowledge of the various forest management options and their likely outcomes, and maintain certain cognitive limitations. The study lists examples in which landowners seemingly act on motivations that can be explained better by the theory of planned behavior, but also show that risk minimization activities such as wildfire mitigation can be explained by rational choice theory. Notably, Aguilar et al. (2017) consider proximal affects proximal of neighboring landowners on FFO decisions within a bounded rationality and theory of planned behavior frameworks. In summation, both theories discussed can describe certain motivators of behavior amongst FFOs, but neither fit squarely enough to be a perfect model of FFO behavior, nor or they mutually exclusive

2.3 Lessons from the FFO biomass literature

In the past decade there has been a significant increase in biomass and biofuel use in energy production (*Biofuels Issues and Trends: October*, 2012). This trend and the research that followed is in part due to the promise that biomass energy could offset the use of fossil fuels to a limited degree. Thus, many studies have investigated the willingness of FFOs to harvest biomass and in doing so have provided a very thorough outline of the relationship between FFOs and biomass harvesting in various regions throughout the United States. The biomass literature is relevant to this study because biomass harvesting involves a suite of specific silvicultural methods. Similar to how a clearcut removes all of the standing trees in a forest stand, a biomass harvest can remove all of the logging slash and woody debris from the forest floor. Of course, like all silvicultural methods, there are variations in how biomass is removed from a stand, and in many studies, FFOs are provided with a variety of factors to consider (e.g. prices, removal frequency and intensity, relation to a commercial harvest, etc.) within a random framework using a choice experiment approach (Aguilar, Cai, & D'Amato, 2014). Preferences for various biomass harvesting options is typically described as a function of their FFO characteristics and attitudes, as well as the attributes of their land, and price (Aguilar et al., 2014).

2.3.1 Factors that influence willingness to harvest biomass

Demographic variables such as a landowner's age, salary, education level, and gender have the potential to play important roles in their willingness to harvest biomass (Gruchy, Grebner, Munn, Joshi, & Hussain, 2012; Joshi & Mehmood, 2011; Paula, Bailey, Barlow, & Morse, 2011). Age was found to be one of the most significant variables in determining a FFO's WTH. Generally, older landowners are less supportive of harvesting biomass from their woodlands. This may be due to their growing attachment to their woodland over the years, or more ideological reasons such as not being supportive of bioenergy or not viewing climate change as a significant threat. Another important demographic variable is education. Many studies have found that education level is positively related to FFO WTH biomass (Gruchy et al., 2012; Joshi & Mehmood, 2011). Landowners with a higher education level are more likely to recognize the potential impact of biomass on energy independence or the threat of climate change.

Important landowner attitudes that predict WTH include perception of ecological impacts of biomass removal on their forest, support of bioenergy, climate change concern, and impact of bioenergy on the local economy. Landowners who felt strongly that biomass would have a negative impact on the soil or water in or around their forested property were much less likely to be willing to harvest biomass (Becker, Eryilmaz, Klapperich, & Kilgore, 2013; Cai, Narine, D'Amato, & Aguilar, 2016; Markowski-Lindsay et al., 2012). In contrast, landowners who felt that the biomass plants would boost their local economy or were concerned about climate change were also more likely to be willing to harvest biomass (Brinckman & Munsell, 2012; Markowski-Lindsay et al., 2012).

Variables often addressed in FFO questionnaires include parcel size, accessibility, and absenteeism. Landowners who owned large acreages of forestland were often more inclined to harvest biomass (Joshi & Mehmood, 2011; Markowski-Lindsay et al., 2012; Paula et al., 2011). These landowners are more likely to have invested in their forestland with the intention of making a financial return and therefore are more likely to be familiar with various aspects of forest management. Absentee landowners (typically defined as

those landowners who live more than 50 miles away from their forestland), were found to be less willing to harvest biomass (Becker et al., 2013; Cai et al., 2016). Absenteeism is usually reflective of landowners who primarily use their land for recreation and may be less willing to disrupt recreation activities with a commercial harvest or have inherited their land and do not have plans for it since they often live far away. None of the studies in this review found forest parcel accessibility to be a significant factor in WTH biomass.

Some of the common variables related to a landowner's forest management activeness include interest in wildlife habitat management, past commercial timber harvest implementation, membership in a forest owner's association, and the existence of a forest management plan. All of the aforementioned variables have been found to have a positive impact on a FFO's WTH biomass (Becker et al., 2013; Cai et al., 2016; Joshi & Mehmood, 2011).

The most significant predictor of landowner WTH biomass is price (Aguilar et al., 2014; Becker et al., 2013; Cai et al., 2016). Regardless of whether price was presented to the landowner on a per acre basis for biomass or lumped in with a commercial timber sale, higher prices significantly fetched higher willingness to harvest from landowners in all studies.

2.4 Importance of forest aesthetics and information on treatment acceptability

A common theme amongst FFOs is the importance of scenic beauty and aesthetics on their forested land (Butler, Hewes, et al., 2016). However, there are few studies that investigate in detail the aesthetic qualities that are important to landowners. Brush (1979) used 20 images from different forest treatments in varying forest types to determine which images were preferred among both landowners and college students with forestry training. The photographs displayed various treatments and conditions, including thinnings in conifer stands, prescribed burns of hardwood stands, and open pasture-like settings. Light thinnings in conifer stands and older unthinned conifer stands made up the top 5 preferred visuals among both landowners and forestry students (Brush, 1979). According to the author, the scenery presented in the top 5 photos are likely preferred due to their "park-like" appearance with relatively clean and open sight lines.

A similar study by Brunson and Reiter (1996) presented office workers and university students in northern Utah with photographs of different ecosystem management approaches in Oregon. The key difference between that study and Brush's (1979) was that the authors considered the impacts of additional information about the treatments depicted in the images on participants' perceptions of scenic quality of forest stands portrayed in those images. The authors assumed that both the university students and the office workers had very little to no previous knowledge of forestry or ecosystem management. Each group was presented a series of 48 photographs depicting harvests of different intensities in seven different forest stands on the McDonald-Dunn Research Forest in Oregon. The treatments ranged from an unharvested old growth forest to partial harvest treatments and clearcuts. The participants were asked to rate the scenic quality of each image on a nine-point scale from most unacceptable to most acceptable. A subgroup from each group received information about ecosystem management silviculture, while the other subgroups merely received instruction, but no information. The results of the study showed a negative relationship between harvest intensity and acceptability. The unharvested old growth stand was the most aesthetically pleasing, whereas the two clearcuts were found to be the least acceptable. The addition of information regarding ecosystem management prior to the images being shown increased acceptability amongst office workers but had the opposite effect on the university students. This effect, as discussed by the authors, may be a result of providing improperly curated information to an audience (Brunson & Reiter, 1996). Logging is not very common in northern Utah and this may have played a significant role in the university students' adverse reactions to the information provided by the authors. In contrast, logging in the Lake States is very common and important economic driver. Therefore, the effects that Brunson and Reiter experienced in their study may be less likely to occur among FFOs in the WUP who may have more experience with forest management.

Peterson and Vaske (2016) investigated Colorado residents' familiarity, aesthetic judgement, and approval of nine common forest management practices. These practices included fire prevention activities such as prescribed fire and fuel breaks, as well as three broad silvicultural treatments; patch cuts, thinnings, and clearcuts. The authors

hypothesized that approval of forest management practices would be positively related to residents' aesthetic judgements and their familiarity with each practice. Three thousand Colorado residents were sampled using three different questionnaires (1000 residents per questionnaire). Each of the three different questionnaires contained a definition from the *Dictionary of Forestry* (Helms, 1998) and images of three of the forest management practices. This was done to reduce respondent burden. The authors analyzed responses to determine the extent of consensus among groups for approval, familiarity, and aesthetics for each forest management practice. The results showed a very high consensus in aesthetic judgements, but a low consensus in familiarity, suggesting similar attitudes for how each treatment looked but different levels of familiarity with the practices among residents. According to respondents, thinnings were found to increase the scenic quality of forests, patch cuts (total removal of trees in an area less than 2.5 acres) were found to be aesthetically neutral, clearcuts (total removal of trees in areas greater than 2.5 acres) were found to reduce the aesthetic quality of a forest. A similar finding occurred with approval; residents generally approved of thinnings, were neutral about patch cuts, and expressed very low approval for clearcuts. Among these three broad silvicultural prescriptions, aesthetic quality was a much stronger predictor of approval than familiarity.

Among landowners and the general public alike, there is a strong affinity for the park-like appearance created by applying thinnings and lighter intensity harvests (Brunson & Reiter, 1996; Brush, 1979; Peterson & Vaske, 2016). The low approval of clearcuts reported by Peterson and Vaske (2017) is also expected in this study. However, interest in single tree selection and shelterwoods is more difficult to predict. It may fall in line with results of the previously discussed studies, in which the park-like appearance of shelterwood receives higher approval than the clearcut. Immediately following a harvest, single tree selection leaves the forest in a similar aesthetic state than before cutting, so FFOs who appreciate the dense nature of a typical northern hardwood stand may find single tree selection appealing. Aesthetics are very important when FFOs consider forest management (Butler, Hewes, et al., 2016; Rouleau, Lind-Riehl, Smith, & Mayer, 2016),

and a further understanding of FFOs aesthetic judgements of specific silvicultural prescriptions should help managers better serve this important group of forest owners.

2.5 Previous research on FFOs in the WUP

In addition to this study, there have been a handful of other studies that focused on FFOs in the Upper Peninsula of Michigan. The two most relevant studies to this research will be covered briefly in this section to provide further context about the landowning populace in the WUP.

Lind-Riehl et al (2015) explored the family legacies and community networks that inform FFO management in the WUP. Specifically, this study sought to determine the role of social influence in management as opposed to the rational choice paradigm that is often used to describe FFO activities. The study was interview based and used data from conversations with 37 FFOs in the WUP. These interviews were semi-structured and included various open-ended questions about the characteristics of their forested land, management activity, social and community relationships, participation in voluntary incentive programs (VIPs, programs that incentivize forest management), and knowledge of forest management. All landowners selected for interviews were enrolled in the commercial forest reserve (CFR) program or other inventive programs. The authors found that landowners who were neighbors often shared similar recreational land use and management activities. These neighbors were often related to one another, which strengthened forest-related norms. In terms of silviculture, there was a strongly negative view of clear cutting among most, but not all, interviewees. There was also a strong Nordic tradition among interviewees, with most having ancestors that hailed from Finland. The authors conclude by stating that social influences, as opposed to rational choices, greatly influence FFO decisions in the WUP and the current methods of VIPs do not accurately capture this.

The second study with strong relevance to my research comes from the same dataset as the previously discussed paper, but focuses mostly on VIPs. Rouleau et al. (2016) investigated the implementation of VIPs and their role in forest management in the WUP. Specifically, the study exposes a strong disconnect between FFO management

interests and motivations, and the incentives included in VIPs. This issue, among others, has created VIPs that have very low enrollment. Current VIP approaches include using incentives such as assistance, tax breaks, and management information to motivate landowners to enroll their land in a given program. However, as the authors state, this only focuses on a narrow group of FFOs who have clearly defined preferences that trend toward active management. In addition to the systemic issues of inadequate funding and outreach, the authors also found a relatively strong anti-government sentiment among FFOs that greatly reduced their interest in participating in VIPs. FFOs whose goals fell outside of timber production also struggled to find relevance in the VIPs offered in Michigan.

2.6 Silviculture

In northern hardwood forests of the Lake States, single tree selection is a commonly implemented silviculture prescription (Pond, Froese, & Nagel, 2014). Single tree selection system, when implemented correctly, maintains an uneven aged stand that is made up of a diverse group of mid to shade tolerant tree species (Nyland, 2007). However, implementation of single tree selection over multiple cutting cycles has been associated with reduced species diversity in northern hardwood forests of the Upper Peninsula by significantly promoting the growth of sugar maple (*Acer saccharum*) over all other tree species (Neuendorff et al., 2007; Schwartz et al., 2005). Furthermore, the Arbogast marking guide (Arbogast, 1957) that has helped to facilitate the selection system in northern hardwood forests for over half a century is not always followed correctly by most landowners in the Great Lakes Region (Pond et al., 2014). Due to these findings, forward thinking managers and researchers are looking to other silvicultural prescriptions and management practices in order to conserve the structural and species diversity of northern hardwood forests in the Lakes States.

Pond, Froese, and Nagel (2014) studied the sustainability of single tree selection in the northern hardwood forests of the Great Lakes Region. The authors used field measurements from family, corporate, and public forests under active management to determine the degree to which Arbogast (1957) and other similar guidelines were being

followed. They hypothesized that state lands would follow the guidelines closest, whereas family forests would be harvested in a variable nature, and corporate lands would feature a higher intensity of cutting in the larger diameter classes. A total of 96 recently harvested stands were selected and sampled using 10 randomly located 100 m^2 circular plots for half of the stands, and 400 m^2 for the other half. Within each plot, conventional forest inventory measurements were taken, including species and diameter at breast height for trees larger than 10 cm, as well as the diameter, height, and species of stumps cut in the most recent harvest. The results showed a large discrepancy between the target structure according to management guidelines and the observed post-harvest structure. Only 23% of the stands were managed in agreement with the Arbogast guideline. The authors explain that this phenomenon is of significant concern as the deviation from the guidelines could result in poor regeneration, a decrease in yield of large diameter timber, and response to disease or pest outbreaks by weakening the overall genetic quality of the forest. Of the FFO properties in the sample, 25% were cut as recommended, 36% were lightly cut overall, in poles, or in sawtimber, and 39% were heavily cut in sawtimber.

Anecdotal evidence based on personal observations and conservations with practicing foresters suggests that clearcuts are rarely the recommended management choice in northern hardwoods, except in cases where it is necessary that a stand be restarted. However, these treatments can be a viable regeneration method. With the risk of invasive species and extreme weather due to climate change, scenarios may arise where a clearcut is the best treatment for a northern hardwood stand. In addition to extreme or uncommon events, clearcuts performed on appropriate sites in northern hardwood forests have been shown to increase diversity in early successional bird species when compared with silvicultural methods that leave higher residual basal area, such as group selection (Costello, Yamasaki, Pekins, Leak, & Neefus, 2000). Landowners and members of the public in the Lake States who hunt are likely familiar with clearcuts in their application to increase habitat for game species such as ruffed grouse (Rouleau et al., 2016). Although these cuts are typically done in aspen stands, they are highly visible

and often adjacent to northern hardwood stands. The social implications of northern hardwood clearcuts is therefore useful to investigate.

Shelterwoods, especially irregular shelterwoods, have been applied to hardwood systems for decades (Raymond, Bedard, Roy, Larouche, & Tremblay, 2009), but their use in the northern hardwoods of the Lake States has not been widely adopted (Pond et al., 2014). In their review, Raymond et al (2009) discuss the appropriate implementation of irregular shelterwoods in forest systems that experience partial disturbance. While this paper is primarily focused on the northeast, many of the same species and stand dynamics exist in the Lake States. The authors suggest that the proliferation of single-tree selection can lead to decreased abundance of mid-tolerant species. As mentioned previously, the "maplelization" of northern hardwoods can lead to significant drop-offs in tree species diversity. The authors argue that irregular shelterwoods could create opportunities for heightened species diversity. They also highlight the ability of irregular shelterwoods to help restart high-graded stands, which is still a concern on family forest land. The concerns of maplelization have also been covered in a recent review paper (Hupperts et al., 2018) that will be discussed subsequently.

2.7 Synthesis

This study acts as the social science companion to a long-term silvicultural study. The impetus and conceptual model for the silvicultural study, titled the Northern Hardwood Silvicultural Experiment to Enhance Diversity (NH-SEED), is outlined by Hupperts, Dickinson, Webster, and Kern (2018). This review discusses the disturbance regimes, complex forest ecology, and historical management of northern hardwood forests, and outlines the need for complex, adaptive management in order to maintain or improve the diversity of these forested systems. The silvicultural methods included in NH-SEED are clearcut, shelterwoods, and single tree selection. These treatments, along with multiple replicates and other silvicultural activities, were implemented during the winter of 2017 on the Ford Forest in Alberta, Michigan.

As these silvicultural methods are explored from a forest ecology perspective, it also important to understand the social relevance of such methods. If methods other than

single-tree selection become a necessary tool to address concerns for species diversity and resilience, it is important to understand the likelihood of implementing them among FFOs, since they control roughly a third of the northern hardwood forest. If FFOs are unwilling to adopt unconventional approaches, it may be challenging to implement large scale changes in management that may benefit the health of the northern hardwood forest. As the social science companion to NH-SEED, this study aims to understand the acceptability of clearcut, shelterwood, and single tree selection methods among FFOs who own northern hardwood forestland in the WUP of Michigan. Images and descriptions of the three general NH-SEED prescriptions were used to elicit FFOs experience, interest, and attitudes of said treatments. A better understanding of FFOs general acceptance of these treatments will help to inform managers and researchers of the potential that these treatments have on family owned northern hardwood forests throughout the region.

3. Methods

3.1 Study area

This study targeted FFOs with ownerships of 20 acres or more of forested land in the WUP of Michigan (Figure 1). This area exhibits relatively consistent land use and forest types, which are primarily northern hardwood forests dominated by sugar maple. The mosaic of forestland ownership in this region includes family, industrial, state, federal, tribal, and NGO forest ownership. The WUP has a long history of natural resource extraction and management, particularly focused on timber, copper, and iron (Fuller, 1926).This area is also home to the largest population of Finnish immigrants in the United States, which has been shown to influence management decision among many FFOs (Lind-Riehl et al., 2015; Schubert & Mayer, 2012).

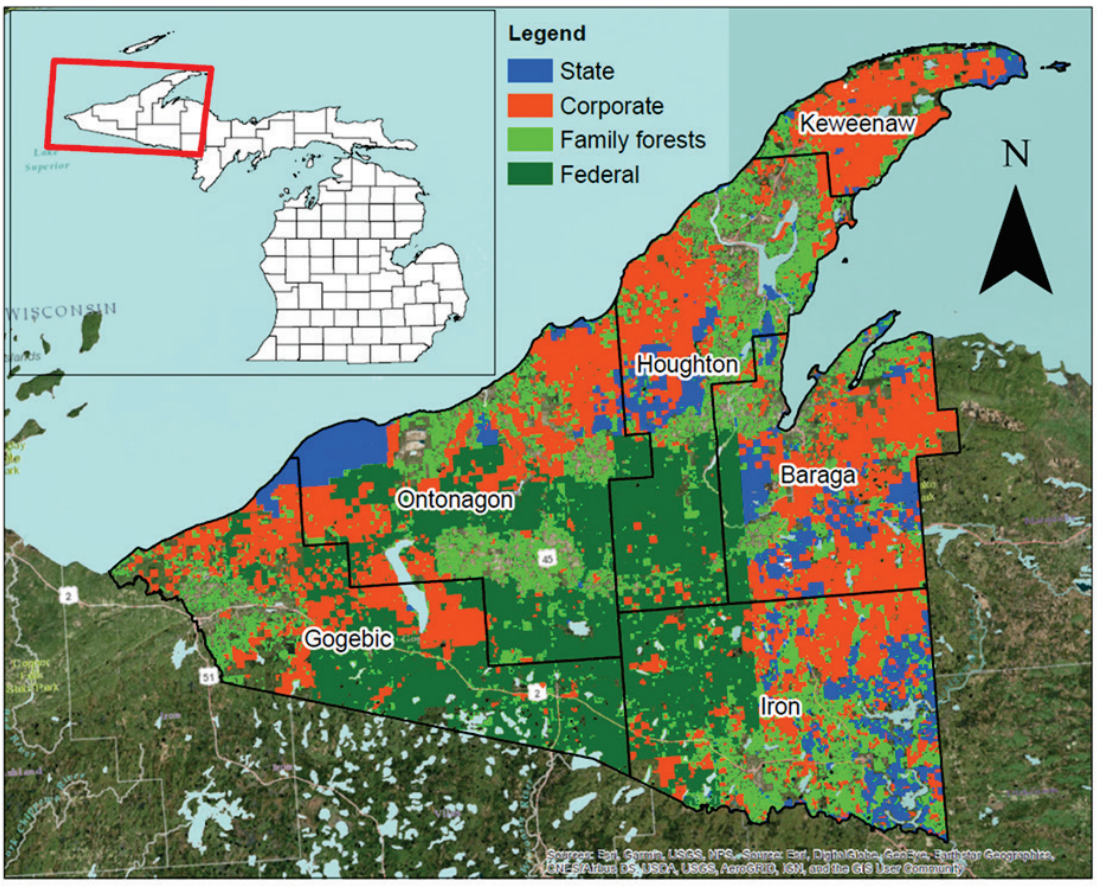

Figure 1: Map of Western Upper Peninsula forest ownership

3.2 Sample selection

Tax parcel data in the form of shapefiles and their associated attribute data (e.g. names and mailing addresses of owners) were acquired for all six counties (Baraga, Gogebic, Houghton, Iron, Keweenaw, and Ontonagon) included in the study. Many of the county level records for the tax data were nearly a decade old, which created some complications as to the certainty of land ownership. All parcels containing at least 20 acres or more of forest were identified using data from the National Land Cover Database (NLCD) (Homer et al., 2015). Next, all public and corporate forestland was removed from the dataset. This was done using keyword searches such as LLC, CO., NATIONAL FOREST, etc. Hunting clubs were also removed from consideration for this study. After significant data cleaning, the remaining parcels were limited to FFOs, which included

estates, family trusts, and conventional ownerships. A mailing list was generated by selecting a simple random sample of 1600 landowners from across the WUP. The estimated total population of landowners who own 20 acres or more is roughly 20,000.

3.3 Survey instrument

The questionnaire used to capture perceptions of three silvicultural treatments was a 16-page survey booklet (Appendix A). The study and survey instrument received appropriate IRB approval and participants were notified of this on the first page of the questionnaire. The questionnaire was divided into three parts. Part 1 included general questions about FFOs' land characteristics such as acreage, tenure, residence, existence of a management plan, and past management activities. It also contained the "reasons for owning forestland" question from the Michigan version of the National Woodland Owner Survey (NWOS) (Butler, Dickinson, et al., 2016). Part 2 started with a definition of silviculture and a description of northern hardwood forests. This description was provided in order to prompt respondents to only consider the areas of their forest that are northern hardwood when answering the silviculture questions. It then asked landowners to rate their familiarity with each of three silvicultural methods - single tree selection, shelterwood, and clearcut. Following the familiarity question were three sections that described and asked questions about each treatment. These sections included a representative image of the treatment captured from the NH-SEED harvest and a description of the treatment using the following parameters; harvest removals, next commercial harvest, tree species favored, and wildlife species favored. The second part for each treatment asked questions about the FFO's experience and interest in the treatment. Part 3 of the booklet had general demographics questions such as age, gender, education, and income. There was also space for landowners to leave comments.

3.4 Implementation

Prior to the full mailing, a pilot mailing was sent to 60 FFOs in Houghton County. The purpose of this pilot was to test the efficacy of our printing and mailing services, as well as the effectiveness of the survey booklet itself. Following the pilot and peer feedback, minor changes were made to the survey booklet. In the full mailing,

landowners were sent a series of postcards and questionnaires using a modification of the Tailored Design Method (Dillman, 2000). The first mailing was a postcard alerting FFOs about their inclusion in the study. This postcard was followed by the first wave of questionnaires. These questionnaires were affixed with a unique identifier that was assigned to each FFO. When survey booklets were returned, the FFO with the corresponding unique identifier was removed from the mailing list. A second wave of questionnaires was sent to non-respondents after 3 weeks. Three weeks following the second wave of questionnaires, a reminder postcard was sent to non-respondents. Finally, a third and final wave was sent to non-respondents three weeks after the reminder postcard.

3.5 Response rate and nonresponse bias assessment

A total of 490 questionnaires were returned from FFOs who own forest in the WUP, resulting in a 31% response rate. Of the returned questionnaires, a total of 454 were sufficiently completed and used in the analysis. To test for nonresponse bias, responses to selected demographic questions were compared using an independent samples t-test comparing early and late respondents (Armstrong & Overton, 1977). This analysis, and all other analyses in this study were performed using IBM's Statistical Package for the Social Sciences (SPSS), version 25 (IBM, 2017). Early respondents were those who responded to the first wave of surveys (n = 308) in less than three weeks, late respondents (n = 176) responded after the initial three weeks. In testing for nonresponse bias, there were no statistically significant differences ($p \leq 0.05$) in acreage owned, distance from forestland, tenure, landowner age, and education between early and late respondents. In addition, there were no significant differences between the two groups in terms of silvicultural knowledge or interest. The only statistically significant difference observed was that late respondents were slightly more likely to own forestland to raise a family and slightly less likely to own forestland in order to pass it on to their children or heirs.

3.6 Data analysis

Responses from returned questionnaires were coded into a database upon arrival. When it was very likely that no further returned questionnaires would arrive, multiple statistical tests were performed on the data using SPSS version 25. In addition to descriptive statistics, ordinal logistic regression and chi-square tests of independence were used to identify key differences among FFOs' experience with, interest in, and acceptability of the three silvicultural methods covered in the questionnaire. Variables and their categories and descriptions can be found in Table 1.

The ordinal logistic regression was performed using responses to the "likelihood to implement" question as a dependent variable. This question asked respondents to indicate the likelihood that they would implement a given silvicultural method on a 10-point scale, where 0 = not at all likely and 10 = extremely likely. In data analysis, the "likelihood" variable was recoded into ordered thirds, with the lowest third being "not likely", followed by "somewhat likely" and "very likely". Responses to the "reasons for owning forestland" question, which required respondents to rate the importance of various forestland attributes and values on a five-point scale (1, not important, to 5, very important), were included in the regression model as predictor variables. Other ordinal predictor variables used in this analysis include education, income, age, acreage, and tenure (Table 2).

Table 1: Descriptions and categories for variables used in analysis. Variables beginning with xx are specific to each method, CC=Clearcut, SS=Single tree selection, SW=Shelterwood.

Variable name	Categories	Description
ACREAGE	1 to 9 acres 10 to 19 20 to 49 50 to 99 100 to 199 200 to 499 500 to 999 1000 to 4999	Total acreage of a respondent's forested land in the WUP
TENURE	1 to 5 years 6 to 15 16 to 25 More than 25 years	Length of time that respondent has owned forested land in the WUP
ABSENTEE	Non-absentee Absentee	Respondent considered absentee if they live more than 200 miles away from forested land in the WUP
LOCATION	Urban Suburban Rural	Location where respondent lives. All respondents who answered that the live on their forested land were automatically classified as "Rural"
MGMTPLAN	Yes No	Does the respondent currently have or ever have had a management plan written by a professional forester
ACTMGMT	Yes No	Has the respondent ever performed active management on their forested land
BEAUTY BIODIVERSITY INVEST PRIVACY FAMILY HEIRS FIREWOOD TIMBER NONTIMBER HUNTING RECREATION	Not important Slightly important Moderately important Important Very important	How important are these reasons for owning forested land in the WUP

Table 1 continued: Descriptions and categories for variables used in analysis. Variables beginning with xx are specific to each method, CC=Clearcut, SS=Single tree selection, SW=Shelterwood.

Variable name	Categories	
CCFAM SSFAM SWFAM	Not at all familiar Slightly familiar Somewhat familiar Moderately familiar Extremely familiar	How familiar is the respondent with the three silvicultural methods
xxCUTSAT	Very dissatisfied Dissatisfied Unsure Satisfied Very satisfied	If the respondent has implemented a given method, how satisfied were they with the results of the harvest
xx10YEARS	Yes No	Would the respondent consider implementing a given method within 10 years
xxLIKELY	Not likely Somewhat likely Very likely	How likely is a respondent to implemenent a given methods with 10 years
xxFINANCE xxWILDLIFE xxRECREATION xxBEAUTY	Not important Slightly important Moderately important Important	How imporant are these factors in a respondents decision to implement a given method
FAVESILV	Clearcut Single tree selection Shelterwood None	Which, if any, method is a respondent most likely to implement
AGE	Less than 45 years 45 to 54 55 to 64 65 to 74 75 years and older	Age of respondent
GENDER	Female Male	Gender of respondent
EDUCATION	Less than 12th grade High school/diploma Some college Associate degree Bachelor's degree Advanced degree	Education of respondent
INCOME	Less than $25,000 $25,000 to $49,999 $50,000 to $99,999 $100,000 to $199,999 $200,000 or more	Income of respondent

Table 2: Variables used in chi-square and regression analysis. Variables beginning with xx are specific to each method, CC=Clearcut, SS=Single tree selection, SW=Shelterwood.

Variable name	Regression	Chi-squa
ACRE	x	x
TENURE	x	x
ABSENTEE		x
LOCATION		x
MGMTPLAN		x
ACTMGMT		x
BEAUTY	x	x
BIODIVERSITY	x	x
INVEST	x	x
PRIVACY	x	x
FAMILY	x	x
HEIRS	x	x
FIREWOOD	x	x
TIMBER	x	x
NONTIMBER	x	x
HUNTING	x	x
RECREATION	x	x
CCFAM	x	
SSFAM	x	
SWFAM	x	
xxCUTSAT	x	
xx10YEARS		x
xxLIKELY	x	
xxFINANCE		x
xxWILDLIFE		x
xxRECREATION		x
xxBEAUTY		x
FAVESILV		x
AGE	x	x
GENDER		x
EDUCATION	x	x
INCOME	x	x

The first chi-square tests of independence were performed using the "preferred silvicultural method" question, which asks landowners to choose the method (or none) from the questionnaire that they would be most likely to implement. Independent variables included age, tenure, acreage, residence, existence of a management plan, and past activities (Table 2). The second chi-square analysis was performed using the

"reasons for owning forestland" and "factors influencing harvest (xxFINANCE, xxBEAUTY, xxRECREATION, xxWILDLIFE)" variables as independent variables and whether landowners would consider implementing a given method within 10 years (xx10YEARS) as the dependent variable.

4. Results

4.1 Sample characteristics

The sample of FFOs surveyed in this study is broadly representative of those at both the state and national scale. The average WUP FFO with 20 acres or more is in their sixties or older, has a household income of between $50k and $99k, is college educated, and is more likely to be a male (Table 3). In terms of forest ownership characteristics, FFOs in this region own larger parcels of land, on average, than those represented by respondents who own 20 or more acres in the NWOS in Michigan and nationwide. Respondents were asked what percentage of their land was made up of coniferous species and hardwood species. Roughly 70% of respondents' forests were made up of deciduous species, with about 30% being coniferous. Further forestland characteristics show that about a third of FFOs in the WUP are absentees (live > 200 miles from forestland in WUP) (Table 4). Comparing absentee rates in this study to FFOs nationwide was not possible due to differences in question design. The NWOS used a much shorter distance as a threshold to designate absentee landowners. The threshold of 200 miles was used in this study due to the remoteness and low population density of the WUP. Similarly, estimates of active management for the NWOS were also not comparable since the NWOS questionnaire did not contain a yes or no question pertaining to past active management like the one that was included in the questionnaire used in this study.

Table 3: Demographic variables of FFOs who own more than 20 acres in the WUP, Michigan, and nationwide. Nationwide and statewide findings were derived from the NWOS Tablemaker

Characteristics (mean)	Our study	NWOS	NWOS Michigan
Age	65 years	55-64 years	65-74 years
Household income	$50k to 99K	$50k to 99K	$50k to 99K
Education	Bachelors	Bachelors	Some college
Gender	Male (84%)	Male (76%)	Male (80%)

The percentage of survey respondents from the WUP who have a management plan are similar to national results, but noticeably higher than the statewide percentage (Table 4). Participation in management plan assistance programs was higher at the national level than in this study or statewide. FFOs in the WUP also participated in tax reduction programs at a higher rate than FFOs statewide, although these programs appear to be more popular outside of Michigan (Table 4).

Table 4: Forestland of FFOs who own more than 20 acres in the WUP, Michigan, and nationwide. Nationwide and statewide findings were derived from the NWOS Tablemaker.

Forestland characteristics (mean or %)	**Our study**	**NWOS**	**NWOS Michigan**
Acreage	107 acres	20-49 acres	20-49 acres
Tenure	29 years	25-49 years	25-49 years
Absentee landowners	32%	-	-
Management plan	27%	29%	18%
Performed active management	78%	-	-
Participated in cost share program †	14%	20%	10%
Participated in tax reduction program ††	14%	28%	5%
Forestland is green certified †††	Less than 2%	5%	Less than 2%

† Cost share programs include Natural Resource Conservation Service CAP 106 and the Michigan Forest Stewardship Program.

†† Tax reduction programs include the Michigan Commercial Forest Program, Michigan Qualified Forest Program, and conservation easements.

††† Green certification programs include the American Tree Farm System, Sustainable Forestry Initiative, and the Forest Stewardship Council

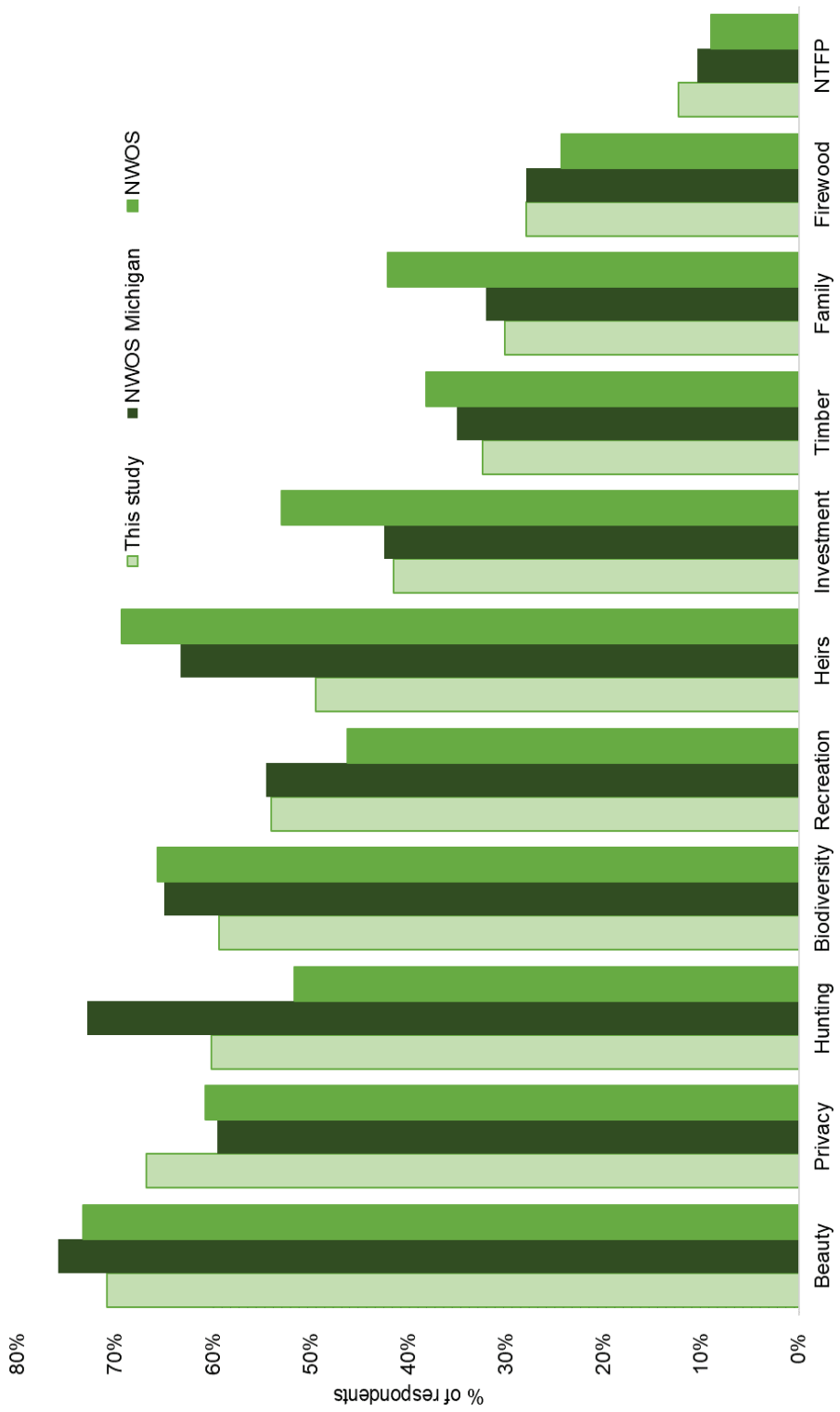

Figure 2: Results from the "reasons for owning forestland" question. NWOS and NWOS Michigan estimates were derive from the NWOS Tablemaker.

The results to the "reasons for owning forestland" questions compared to national and statewide estimates can be found in Figure 2. Notable differences include the observation that more Michigan and WUP FFOs rank hunting as important and very important than the FFOs nationwide. Inversely, heirs and family are less important to WUP FFOs.

Respondents were asked a series of questions pertaining to silviculture. The first of these questions was designed to assess respondents' familiarity with the names of the three silvicultural methods covered in the survey. Figure 3 displays the percentage of respondents who ranked their familiarity from slight to extreme for each term, as well as the respondents' previous experience with each method. Although FFOs were very familiar with the term clearcut, only 11% reported implementing the method on their property (Figure 3). Single tree selection was implemented by over half of the

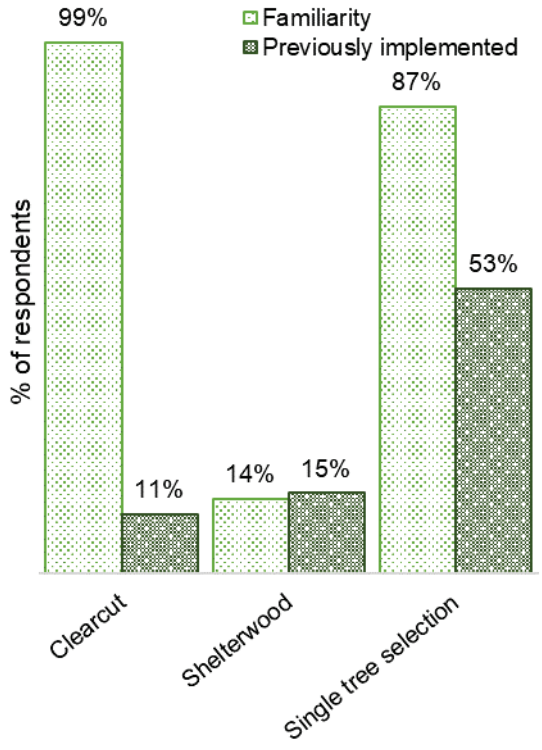

Figure 3: Respondents' familiarity (slightly to very familiar) and previous experience with silvicultural methods.

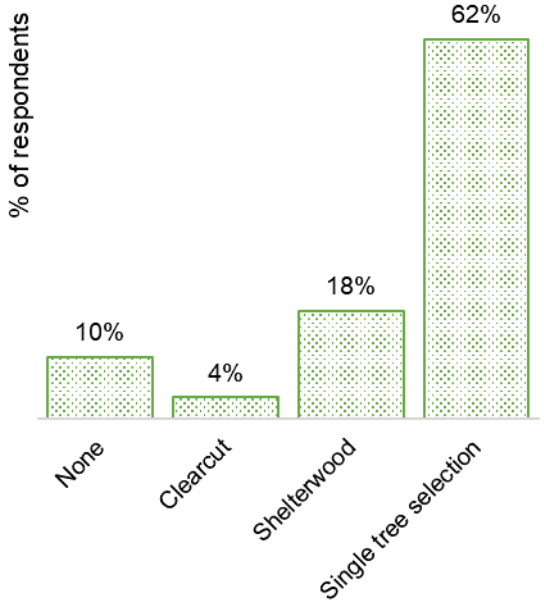

Figure 4: Respondents' preferred silvicultural method after information given in questionnaire

respondents. The percentage of respondents familiar with the shelterwood method appears to be limited to FFOs who have actually implemented it.

Table 5: Respondents experience with and future likelihood of implementing clearcut, shelterwood and single tree selection.

	Clearcut	Shelterwood	Single tree selection
Previously implemented†	11%	15%	53%
Satisfaction			
Very dissatisfied	4%	5%	5%
Dissatisfied	2%	3%	2%
Unsure	21%	5%	6%
Satisfied	41%	57%	48%
Very satisfied	32%	29%	39%
Future implementation††			
Not likely	82%	62%	31%
Somewhat likely	11%	22%	23%
Very likely	7%	17%	46%

† Respondents have implemented a method at any point previous to survey.
†† Respondents' likelihood of implementing a method within the next 10 years.

After landowners were presented with all silvicultural methods, they were asked which one, if any, they would be most likely to implement on their own land in the future. A majority of respondents chose single tree selection (62%) (Figure 4), while only 4% of respondents chose clearcut as their most preferred option, though 7% of respondents reported that they were very likely to implement a clearcut within the next 10 years.

Satisfaction rates among those who have implemented the methods previously were relatively high. Across all three methods, at least 70% of the respondents who implemented a given method were satisfied or very satisfied with the results of the harvest (Table 5). The likelihood of future implementation within 10 years, also displayed in Table 5, is very low for clearcut, low for shelterwood, and moderate for single tree selection. Figures 4 and 5 and Table 5 show a theme that remains visible throughout the more robust analyses. This theme is the increasing interest, acceptability, and previous implementation as the methods decrease in intensity.

At the end of each silviculture page, respondents' were asked how important four factors were in influencing their decision whether to harvest timber using that method (Figures 5, 6 & 7). Respondents appeared to have similar concerns for wildlife, recreation, and natural beauty for shelterwood and single tree selection as both positive and negative factors that may influence likely implementation. Finance was a relatively consistent concern across all three methods, with roughly a third of respondents selecting this as an important reason to implement a given method, which is much less than any of the other factors for single tree selection and shelterwood. Importance of scenic beauty are the strongest factor in influencing landowners not to implement both clearcut (72%) and shelterwood (59%), whereas concerns about wildlife habitat are the highest for those choosing not to implement single tree selection (57%).

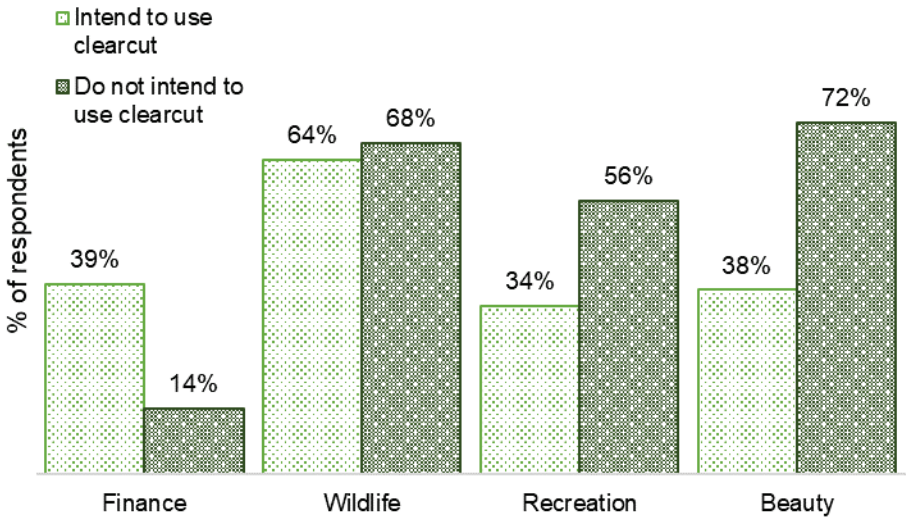

Figure 5: Factors influencing respondents' decision whether to harvest using clearcut within 10 years. Chart captures respondents who ranked factors as important or very important in their decision.

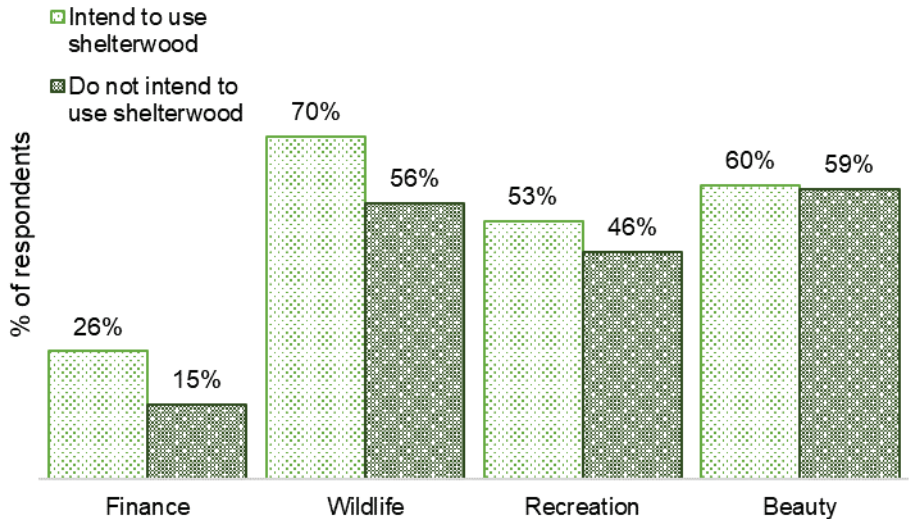

Figure 6: Factors influencing respondents' decision whether to harvest using shelterwood within 10 years. Chart captures respondents who ranked factors as important or very important in their decision.

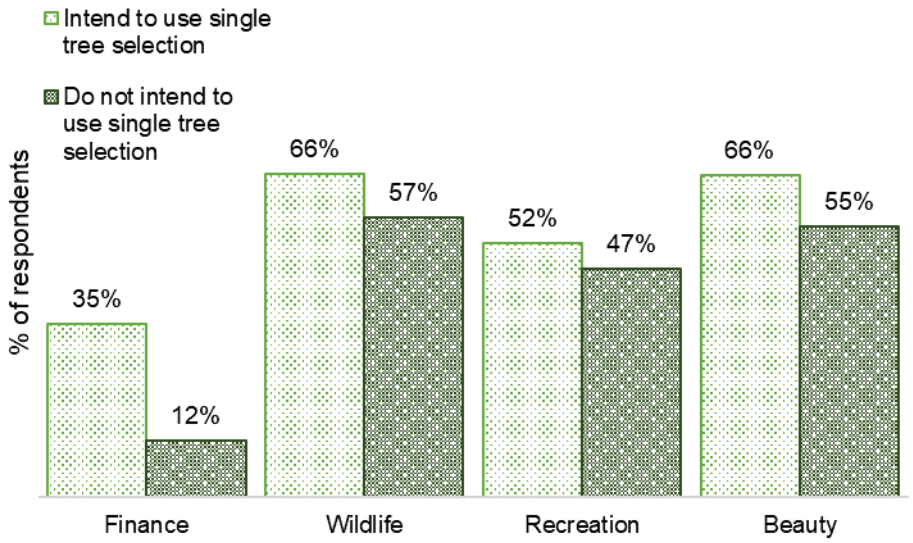

Figure 7: Factors influencing respondents' decision whether to harvest using shelterwood within 10 years. Chart captures respondents who ranked factors as important or very important in their decision.

4.2 Chi-square test of independence

4.2.1 Demographic variables

Multiple chi-square tests were performed using variables shown in Table 6. Results presented in this section represent interesting or significant findings relating to FFOs' preferred silvicultural method, as indicated by the method they were most likely to

implement. According to the analysis, several demographic variables are associated with the silvicultural method that was most likely to be implemented. Respondents with a lower income (less than $25,000) were more likely to choose no management. When considering gender, no female respondents chose clearcut and a much higher percentage of female respondents chose no management. Education and age did not significantly differ among groups.

Residence also seemed to play a role in silvicultural preference. A higher percentage of absentee landowners were interested in shelterwood than non-absentees, who seemed to prefer single tree selection much more. Finally, single tree selection was the favored method among rural residents, whereas suburban residents appeared to prefer shelterwood more than the expected frequencies generated by chi-square. Acreage, management plans, past management activity, and land tenure did not show any significant difference among cohorts.

Table 6: Results from chi-square tests of independence selected demographic variables and the silvicultural treatment that the respondent was most likely to implement within 10 years. Analysis includes observed n and (%) are displayed for each row. Bonferroni's post hoc test and adjusted z scores were used to derive significant differences among values.

Variable	Clearcut	Shelterwood	Single tree selection	None	Total	χ^2	p
INCOME						24.24	<0.05
Less than $25,000	4 (9.8)^{ab}	6 (14.6)^{ab}	22 (53.7)$^{a,-}$	9 (22.0)$^{b,+}$	41 (100.0)		
$25,000 to $49,999	4 (3.9)^{a}	14 (13.7)^{a}	71 (69.6)^{a}	13 (12.7)^{a}	102 (100.0)		
$50,000 to $99,999	6 (3.8)^{a}	31 (19.4)^{a}	115 (71.9)^{a}	8 (5.0)$^{b,-}$	160 (100.0)		
$100,000 to $199,999	3 (4.6)^{a}	16 (24.6)^{a}	42 (64.6)^{a}	3 (6.2)^{a}	64 (100.0)		
$200,000 or more	0 (0.0)^{a}	10 (31.3)^{a}	19 (59.4)^{a}	3 (9.4)^{a}	32 (100.0)		
GENDER						7.994	<0.05
Male	17 (4.5)^{a}	68 (18.0)^{a}	258 (68.3)^{a}	35 (9.3)$^{a,-}$	378 (100.0)		
Female	0 (0.0)^{a}	16 (22.9)^{a}	42 (60.0)^{a}	12 (17.1)$^{a,+}$	70 (100.0)		
ABSENTEE						22.389	<0.001
Non-absentee	14 (4.5)^{ab}	41 (13.3)$^{a,-}$	223 (72.2)$^{b,+}$	31 (10.0)^{ab}	308 (100.0)		
Absentee	3 (2.10)^{ab}	44 (31.0)$^{a,+}$	78 (54.9)$^{b,-}$	17 (12.0)^{ab}	142 (100.0)		
LOCATION						18.019	<0.01
Urban	3 (6.7)^{a}	11 (24.4)^{a}	27 (60.0)^{a}	4 (8.9)^{a}	45 (100.0)		
Suburban	3 (3.3)^{ab}	28 (31.1)$^{a,+}$	46 (51.1)$^{b,-}$	13 (14.4)^{ab}	90 (100.0)		
Rural	11 (3.5)^{ab}	46 (14.6)$^{a,-}$	225 (71.7)$^{b,+}$	32 (10.2)^{ab}	314 (100.0)		

$^{+}$ Observed value is significantly larger ($p<0.05$) than expected value

$^{-}$ Observed value is significantly smaller ($p<0.05$) than expected value

Each superscript letter denotes a subset of row categories whose column proportions do not differ significantly from each other at the 0.05 level.

4.2.2 Motivational variables

The second chi-square analysis involved associations between the various motivational variables such as the reasons for owning forestland questions and the factors influencing harvest decision questions with the decision whether to harvest using a given method with 10 years (see Appendix A for questionnaire). An analysis was performed for each method and the results can be found in Tables 7, 8, and 9. For the clearcut and shelterwood methods, finance had a significant association with influencing landowners decisions, whether they choose for or against implementing either method (Table 7 & 8). With the clearcut method, it appears that financial considerations were not an important factor in most respondents, 86% of respondents who said it was not important factor also choose not to harvest. Finance also had a significant association with implementation of single tree selection, although there was a slightly higher percentage of respondents considering implementing the method than clearcut or shelterwood (Table 9). Wildlife habitat also appears to be a relatively low motivator with shelterwood implementation. Although most respondents ranked wildlife habitat as an important consideration, interest in implementing shelterwood was split relatively evenly in each group (Table 8).

Table 7: Results from chi-square tests of independence for motivational variables and respondents interest in implementing a **clearcut** within 10 years. Analysis includes observed n and (%) are displayed for each row. Bonferroni's post hoc test and adjusted z scores were used to derive significant differences among values.

Variable	No	Yes	Total	χ^2	p
BEAUTY				12.47	<0.001
Not important	89 (70.6)$^{a,-}$	37 (29.4)$^{b,+}$	126 (100.0)		
Important	285 (85.1)$^{a,+}$	50 (14.9)$^{b,-}$	335 (100.0)		
BIODIVERSITY				11.83	<0.001
Not important	128 (72.7)$^{a,-}$	48 (27.3)$^{b,+}$	176 (100.0)		
Important	241 (85.8)$^{a,+}$	40 (14.2)$^{b,-}$	281 (100.0)		
TIMBER				5.38	<0.05
Not important	257 (83.7)$^{a,+}$	50 (16.3)$^{b,-}$	307 (100.0)		
Important	115 (74.7)$^{a,-}$	52 (25.3)$^{b,+}$	154 (100.0)		
CCFINANCE				30.52	<0.001
Not important	313 (85.8)$^{a,+}$	52 (14.2)$^{b,-}$	365 (100.0)		
Important	52 (59.8)$^{a,-}$	35 (40.2)$^{b,+}$	87 (100.0)		

$^{+}$ Observed value is significantly larger ($p<0.05$) than expected value

$^{-}$ Observed value is significantly smaller ($p<0.05$) than expected value

Each superscript letter denotes a subset of row categories whose column proportions do not differ significantly from each other at the 0.05 level.

Table 8: Results from chi-square tests of independence for motivational variables and respondents interest in implementing a **shelterwood** within 10 years. Analysis includes observed n and (%) are displayed for each row. Bonferroni's post hoc test and adjusted z scores were used to derive significant differences among values.

Variable	No	Yes	Total	χ^2	p
BEAUTY				7.33	<0.01
Not important	48 (40.0)$^{a,-}$	72 (60.0)$^{b,+}$	120 (100.0)		
Important	177 (54.5)$^{a,+}$	148 (45.5)$^{b,-}$	325 (100.0)		
SWFINANCE				7.54	<0.01
Not important	181 (53.2)$^{a,+}$	159 (46.8)$^{b,-}$	340 (100.0)		
Important	35 (37.2)$^{a,-}$	59 (62.8)$^{b,+}$	94 (100.0)		
SWWILDLIFE				5.53	<0.05
Not important	86 (57.0)$^{a,+}$	65 (43.0)$^{b,-}$	151 (100.0)		
Important	130 (45.1)$^{a,-}$	158 (54.9)$^{b,+}$	288 (100.0)		

$^{+}$ Observed value is significantly larger ($p<0.05$) than expected value

$^{-}$ Observed value is significantly smaller ($p<0.05$) than expected value

Each superscript letter denotes a subset of row categories whose column proportions do not differ significantly from each other at the 0.05 level.

Timber was a significant consideration for respondents choosing to implement single tree selection (Table 9). Nearly 90% of respondents who ranked timber as an important reason for owning forestland responded that they would consider implementing single tree selection within 10 years. Similarly, nearly 85% of respondents who ranked firewood as an important reason for owning forestland would consider implementing single tree selection.

Table 9: Results from chi-square tests of independence for motivational variables and respondents interest in implementing a **single tree selection** within 10 years. Analysis includes observed n and (%) are displayed for each row. Bonferroni's post hoc test and adjusted z scores were used to derive significant differences among values.

Variable	No	Yes	Total	χ^2	p
PRIVACY				3.91	<0.05
Not important	23 (16.3)$^{a,-}$	118 (83.7)$^{b,+}$	141 (100.0)		
Important	78 (24.6)$^{a,+}$	239 (75.4)$^{b,-}$	317 (100.0)		
FIREWOOD				4.68	<0.05
Not important	80 (24.7)$^{a,+}$	244 (75.3)$^{b,-}$	324 (100.0)		
Important	20 (15.4)$^{a,-}$	110 (84.6)$^{b,+}$	130 (100.0)		
TIMBER				15.58	<0.001
Not important	83 (27.1)$^{a,+}$	223 (72.9)$^{b,-}$	306 (100.0)		
Important	17 (11.0)$^{a,-}$	137 (89.0)$^{b,+}$	154 (100.0)		
RECREATION				4.34	<0.05
Not important	35 (17.7)$^{a,-}$	163 (82.3)$^{b,+}$	198 (100.0)		
Important	67 (25.9)$^{a,+}$	138 (74.1)$^{b,-}$	259 (100.0)		
SSFINANCE				19.14	<0.001
Not important	82 (26.1)$^{a,+}$	232 (73.9)$^{b,-}$	314 (100.0)		
Important	12 (8.3)$^{a,-}$	132 (91.7)$^{b,+}$	144 (100.0)		

$^{+}$ Observed value is significantly larger ($p<0.05$) than expected value

$^{-}$ Observed value is significantly smaller ($p<0.05$) than expected value

Each superscript letter denotes a subset of row categories whose column proportions do not differ significantly from each other at the 0.05 level.

4.3 Ordinal logistic regression

According to the ordinal regression analysis, FFOs who rated "protecting nature and biodiversity" as well as "passing land on to heirs" as important reasons for owning forests were significantly less likely to implement clearcut method, as indicated by exp B values of less than zero (Table 10). Older landowners were also less likely to implement a clearcut. Positive predictors for clearcut implementation included timber and hunting being important to respondents, as well as landowners who owned larger amounts of forested acreage.

There were no significant negative predictors for likelihood to implement the shelterwood method. FFOs who ranked timber and hunting as important reasons for owning forestland were again more likely to implement this method. Landowners who had a higher income were also more likely to be interested in performing a shelterwood on their property.

Table 10: Results from ordinal logistic regression analysis. Exp(B) reflects the odds of a change in likelihood when moving up or down in importance value.

	Clearcut				**Shelterwood**				**Single tree selection**			
Variable	Exp(B)	Lower bound	Upper bound	n	Exp(B)	Lower bound	Upper bound	n	Exp(B)	Lower bound	Upper bound	n
BEAUTY	0.78	0.58	1.06	412	0.93	0.72	1.19	403	1.09	0.86	1.39	413
BIODIVERSITY	0.73*	0.56	0.96	412	0.96	0.78	1.19	403	0.88	0.71	1.08	413
INVEST	1.09	0.86	1.36	412	0.93	0.78	1.10	403	0.87	0.75	1.03	413
PRIVACY	1.22	0.93	1.59	412	1.13	0.93	1.38	403	1.01	0.84	1.21	413
FAMILY	1.25	0.99	1.57	412	1.05	0.89	1.24	403	0.97	0.83	1.13	413
HEIRS	0.69***	0.56	0.87	412	0.87	0.74	1.01	403	0.97	0.84	1.13	413
FIREWOOD	0.83	0.66	1.04	412	1.00	0.85	1.18	403	1.26**	1.08	1.48	413
TIMBER	1.28*	1.02	1.61	412	1.27**	1.07	1.50	403	1.54***	1.31	1.81	413
NTFP	1.00	0.77	1.31	412	1.04	0.85	1.26	403	1.15	0.95	1.40	413
HUNTING	1.30*	1.05	1.62	412	1.18*	1.01	1.37	403	1.07	0.93	1.22	413
RECREATION	1.06	0.82	1.36	412	0.96	0.79	1.15	403	0.99	0.83	1.18	413
xxFAM†	1.11	0.78	1.59	372	0.96	0.84	1.10	364	1.12	0.97	1.29	373
EDUCATION	0.95	0.77	1.17	372	0.89	0.76	1.04	364	1.06	0.91	1.23	373
INCOME	1.00	0.74	1.36	372	1.30*	1.03	1.64	364	1.01	0.81	1.26	373
ACREAGE	1.41**	1.10	1.81	372	1.20	1.00	1.45	364	1.31**	1.09	1.58	373
AGE	0.63***	0.49	0.82	372	0.90	0.74	1.10	364	0.71***	0.59	0.86	373
xxCUTSAT†	0.49	0.16	1.14	52	1.98*	1.17	3.34	72	2.10***	1.59	2.70	239

* Denotes signifiance of p<0.05

** Denotes significance of p<0.01

*** Denotes signifcance of p<0.001

† Variables are specific to method

Single tree selection was preferred by landowners who ranked timber and firewood as important reasons for owning their forestland. Acreage was again a significantly positive predictor for this management option. Much like shelterwood, age was a significantly negative predictor. Landowners who reported being satisfied with previous harvests using shelterwood and single tree selection were more likely to implement each method. Satisfaction with previous harvests was the largest significant predictor of implementing single tree selection within 10 years at 2.10 with a confidence level of 99.9% and similarly for shelterwood at 1.98 with a confidence level of 90%.

4.4 Post-hoc demographic analysis

There were two of the "reasons for owning forestland" variables that stood out in the chi-square and regression analysis. Table 11 highlights the demographic make-up of these two groups of FFOs. Respondents who ranked timber as an important reason for owning forestland, owned larger parcels on average (166 acres) and had a lengthy tenure of ownership (33 years) than both the average respondent and respondents who ranked hunting as important. Also, a higher percentage (40%) of respondents who ranked timber as important had management plans. Respondents who ranked timber as important reason were slightly less educated on average (split between high school and some college) and made up a higher percentage of all respondents (62%).

Table 11: Average demographic and forested land characteristics of landowners who ranked hunting and timber as important reasons for owning forestland. Captures respondents who ranked timber and hunting as "Important" or "Very important".

Characteristics (mean or %)	Timber	Hunting	All respondents
% of respondents	34%	62%	100%
Age	65 years	64 years	65 years
Household income	$50k to 99K	$50k to 99K	$50k to 99K
Education	Bachelors	High school/Some college	Bachelors
Gender	Male (86%)	Male (90%)	Male (84%)
Acreage	166 acres	106 acres	107 acres
Tenure	33 years	28 years	29 years
Absentee landowners	27%	30%	32%
Management plan	40%	28%	27%
Performed active management	85%	80%	78%
Participated in cost share program †	19%	13%	14%
Participated in tax reduction program ††	19%	14%	14%
Forestland is green certified †††	Less than 2%	2%	Less than 2%

† Cost share programs include Natural Resource Conservation Service CAP 106 and the Michigan Forest Stewardship Program.

†† Tax reduction programs include the Michigan Commercial Forest Program, Michigan Qualified Forest Program, and conservation easements.

††† Green certification programs include the American Tree Farm System, Sustainable Forestry Initiative, and the Forest Stewardship Council.

4.5 Comments left by respondents

The comment space at the end of the survey was used by 115 respondents. Although there was no prompt for these comments other than "feel free to leave comments here", most of the comments left behind were accepting of forest management. Many respondents wanted information about how to properly manage their forestland or

contact a forester. Others left long comments detailing the history of ownership and management on their forestland.

There were also a smaller, yet significant, amount of comments that detailed negative views or experiences with forest management. One landowner detailed a rather unfortunate experience where the "forester only cut the valuable trees", or another where the "logger left a huge mess", and "logging is the last refuge of the scoundrel". Further comments illustrated the bureaucratic challenges of enrolling in various tax programs or gaining management assistance.

Comments pertaining specifically to silviculture were few. When "clearcut" was mentioned, it was mostly in a negative context or as something the landowner would be forced to do for financial reasons. "Single tree selection" and its variety of colloquial synonyms were used more frequently than "clearcut". Many respondents who left comments mentioned having some form of a selection system implemented on their land. "Shelterwood" was only mentioned by fewer than 5 respondents. One respondent said that after learning about shelterwood in the survey, they were going to talk to their forester about implementing it on their property.

5. Discussion

5.1 WUP FFOs in this study

Demographically, the nationwide profile of the average FFO, according to results from the NWOS, seems to fit just as well for FFOs with forest in the WUP who participated in this study. Although no statistical test between datasets differences are most noticeable in the motivations behind owning forestland. FFOs in this study appear to have a higher preference for privacy, hunting, and recreation than FFOs nationwide. These motivations are likely due to the character of the forested land in the region. As mentioned previously, the WUP has a very low population density and very high forest cover. These characteristics allow for a great deal of privacy, as well as enhanced hunting opportunities. Barriers to recreation, especially in the form of motor sports, are very low and the WUP, which has a widespread trail network across public and private land ownerships.

On average, FFOs who participated in this study have larger parcels. However, this finding may be biased due to the large landowners in the WUP who own their forestland as an investment and could be more likely to respond to a forestry survey. Larger parcel size may also play a role in the higher rate of management plans among FFOs in this study when compared to FFOs throughout Michigan. Both the Michigan Commercial Forest program (CF) (*Commercial Forest Summary*, 2018) and the Michigan Qualified Forest Program (QFP) (*Qualified Forest Program Brochure*, 2015) require landowners to have a management plan in order to receive tax abatements on their contiguous forestland of at least 20 acres for QFP or 40 acres for CF. The percentage of landowners enrolled in these programs is nearly 3 times that of landowners statewide.

5.2 Familiarity with silviculture and the terminology conundrum

Silviculture, like many other disciplines, relies heavily on the proper use of terminology. This terminology is also perpetually evolving, which complicates communication and knowledge transfer. Anecdotal evidence has shown that even amongst foresters, there are multiple synonyms for the silvicultural term "single tree selection". For example, the terms "selective cut", "selective harvest", and "select cut" have all been used to describe single tree selection. Note, the term "selective harvest", is generally discouraged because of its association with the practice of high-grading, which can degrade a stand, and is therefore not considered an application of silviculture. This ambiguity is problematic because single tree selection has the dual requirement of tending to immature age classes while regenerating mature age classes (Nyland, 2007)and thus relies on specific target residual stand structure across diameter classes (Arbogast, 1957) for determining which trees to cut and which to leave. In contrast, a high grade involves the removal of only the highest quality trees, which significantly reduces the quality of the residual stand with implications for regenerating genetically inferior trees. The potential confusion among landowners around the term single tree selection warrants further investigation to better understand their preferences for that treatment type.

The term "clearcut" is well known, unsurprisingly, to almost all the FFOs that responded to the survey (Figure 3). This term is particularly infamous among the general

public and landowners alike. The negative press surrounding “clearcut” has even led certain regions of the Forest Service to consider an internal ban of the use of the term when discussing forest management (Clausen & Schroeder, 2004). However, it is well known to those who understand silviculture that implementing clearcut method can be an appropriate approach for achieving certain management objectives.

Respondents were least familiar with the term “shelterwood”. In fact, it appears that familiarity is limited to landowners who reported implementing shelterwood. This is not surprising, since shelterwood as a silvicultural system is not commonly used to manage northern hardwoods in the WUP. Also, its name does not lend an image of the harvest as easily as single tree selection or clearcut – treatments whose outcomes are likely easier to deduce based on their names. Acceptance of shelterwood as discussed in the survey was relatively mixed, suggesting that despite the information provided in the survey, respondents were only slightly interested in this method. Despite the relatively low familiarity with and interest in shelterwood method, the finding that respondents who were satisfied with previous experiences with shelterwood suggests an opportunity for outreach and education regarding shelterwood method.

Landowners in this study claimed to be familiar with the term “single tree selection” (Figure 3). This is likely the case because single tree selection is the most widely used silvicultural prescription in the northern hardwoods of the WUP. However, there may be some confusion with the term among respondents. Note, landowners who rated firewood as an important reason for owning forest land were more likely to implement single tree selection than either of the other methods (Table 10). It may be that respondents were interpreting this method as merely selecting a few trees per year to use for firewood, instead of the full silvicultural method. However, given that single tree selection removes both large, sawtimber-grade trees, as well as smaller, low-grade trees better suited for pulp markets or firewood, this result could also reflect an understanding of the type of products that single-tree selection produces.

5.3 Experience with silviculture and willingness-to-implement

5.3.1 Clearcut

Respondents with large parcels were more likely to use a clearcut. The literature has clearly shown a correlation between parcel size and willingness to harvest, so this finding is by no means surprising (Joshi & Mehmood, 2011; Markowski-Lindsay et al., 2012; Paula et al., 2011). That finding is also supported in the ordinal logistic regression by respondents who rank timber as an important reason for owning forestland being more likely to implement a clearcut (Table 10). Aging landowners were significantly averse to clearcuts. Previous studies support this finding in regard to general willingness to harvest (Gruchy et al., 2012; Joshi & Mehmood, 2011; Paula et al., 2011). Respondents rank passing their land to heirs as important had the lowest significantly less likely to implement a clearcut (odds ratio = 0.69, $p<0.001$) (Table 10).

Although most respondents were familiar with the term clearcut, it was the method that respondents were least likely to implement. Much like the findings from other forest aesthetic studies familiarity does not typically predict approval (Brunson & Reiter, 1996; Brush, 1979; Peterson & Vaske, 2016). According to the results of the ordinal regression and chi-square analysis, it does appear that the benefits to wildlife species that clearcuts provide may have been important to FFOs who ranked hunting as an important reason for owning forested land, or who indicated that wildlife was an important factor for their likely decision to implement a clearcut. For instance, 64% who indicated they would consider implementing a clearcut in the next 10 years claimed that wildlife would be an important factor in that decision (Figure 5). As mentioned in the survey booklet (Appendix A), clearcuts can provide important early successional habitat for many wildlife species. This is especially true for important game species like ruffed grouse (*Bonasa umbellus*), white-tailed deer (*Odocoileus virginianus*), and woodcock (*Scolopax minor*). However, 68% of respondents who were not likely to implement a clearcut in the next 10 years also claimed that wildlife would be an important factor in their decision. Thus, it appears that attitudes towards clearcuts are motivated by the specific wildlife habitat they wish to maintain. Furthermore, respondents who thought protecting nature was important were much less likely to implement a clearcut. These

respondents are likely conjuring the images of improper clearcuts of the past, or incorrect portrayals by the media where a clearcut means absolute devastation of the land. These landowners likely preferred the methods that were less intrusive. However, due to the concerns regarding single tree selection and maplelization, clearcuts may provide more biodiversity by creating important young forest habitat, than less aggressive methods.

5.3.2 Shelterwood

Respondents were the least familiar with the shelterwood method. Nevertheless, several significant factors emerged that predicted likely implementation of shelterwood method. Again, FFOs who ranked timber as an important reason for owning forestland were more likely to implement this method. In addition, respondents who had implemented a shelterwood in the past and were satisfied with the results of the harvest, were more likely to report interest in implementing a shelterwood in the future. It also worth noting that although "scenic beauty" is a reason why many FFOs own forestland, it had no significant bearing on the likelihood of implementing a shelterwood, or any silvicultural method covered in the study. However, of those respondents who would consider implementing shelterwood in the next 10 years, 70% indicated that wildlife was an important factor in that decision, suggesting that a subset of landowner found the shelterwood method as being compatible with their wildlife interests.

There were some other interesting findings pertaining to the shelterwood method. Of the 15% of respondents who reported implementing a shelterwood in the past (Figure 3), 86% were satisfied or very satisfied with the result (Table 5). Only 14% of respondents indicated being familiar with the method prior to the image and the description, and 18% reported it to be the method they would be most likely to implement (Figure 4). Results from the chi-square and regression analyses found that respondents with a higher income were more likely to implement this method (Tables 6 & 10), although financial considerations did seem to play a role in whether respondents would consider implementing the method (Table 8). Other studies, however, has shown that landowners with higher incomes were more likely to engage in forest management activity (Romm, Tuazon, & Wahburn, 1987; T. J. Straka & Doolittle, 1988). This makes

it difficult to distinguish why shelterwood implementation specifically would be related to income more so than any other method.

Studies that have specifically investigated absentee landowner attitudes and objectives have shown that recreation and aesthetics were among the more important items considered when making management decisions (Petrzelka, Buman, & Ridgely, 2009; Petrzelka, Ma, & Malin, 2013). Shelterwood harvests typically have a strong aesthetic appeal due to their park-like appearance immediately following the harvest (the image used in the survey was taken during the summer following the harvest). However, scenic beauty was not a significant variable for predicting likely implementation of the shelterwood method.

5.3.3 Single tree selection

The single tree selection method is the most commonly implemented silvicultural prescription in the northern hardwood forests of the WUP (Pond et al., 2014). FFOs in the region are likely very familiar with this method, as indicated by participants' responses to the familiarity question (Figure 3). Respondents who indicated firewood as an important reason for owning forestland, were more likely to implement single tree selection. As discussed earlier, this could be a result of confusion regarding terminology. FFOs who ranked timber as an important reason for owning forestland were also significantly more likely to implement single tree selection, with a likelihood value (1.54, $p<0.001$) higher than any of the other reasons for owning forestland" (Table 10). Landowners with larger acreages and previous experience with single tree selection are more likely to implement it again, which is not surprising given that 87% of respondents who reported having implemented single tree selection in the past were either satisfied or very satisfied with the outcome (Table 5).

An additional important finding from the ordinal regression showed that respondents who had a positive experience with a previous harvest were significantly more likely to implement single tree selection in the future (odds ratio = 2.10, $p<0.001$) (Table 10). As with shelterwood, landowners who ranked a higher satisfaction with the harvest result, were more likely to have a higher likelihood of future implementation. The

comments left by respondents demonstrated anecdotally that FFOs occasionally have negative experiences with loggers and foresters. The importance of a positive experience cannot be understated when it comes to keeping landowners engaged in managing their forestland properly. Not only do positive experiences make an individual landowner more likely to harvest timber, it may also have a positive influence on their landowning neighbors. This demonstrates the importance of accountability among forestry professionals. For loggers, performance bonds, master logger training, and certification can provide accountability and trust among foresters and landowners who may employ them. For consulting foresters, maintain a good reputation and providing positive references could help alleviate concerns among landowners. Moreover, maintaining certification status via the Society of American Foresters, Association of Consulting Foresters, or as group certifications from the American Tree Farm System or Forest Stewardship Council, can help communicate a commitment to ethical and sound forestry practices to landowners. Finally, FFOs seeking a positive experience with forest management would benefit greatly from understanding their state's best management practices for forestry and visiting areas where they can see the results of a good harvest, such as a model or research forest in their community (Germain, Munsell, & Brazill, 2007). This is especially true when more complex silvicultural methods are being considered, where excellence on the part of the logger and forester is crucial to a good cut.

Although the Pond et al study in 2014 found that single tree selection was the most commonly implemented method in the northern hardwood forests, they also found that it was often implemented improperly. Only 25% of harvests on family forestland audited in their study were cut in accordance with the Arbogast (1957) guidelines. Although these guidelines are relatively strict concerning diameter distributions of standing timber, it is possible to adapt single-tree selection to include additional silvicultural activities that might help increase species diversity while still appealing to FFOs in the region. For example, canopy gaps can be intentionally created, under represented species can be planted in the understory, and various methods of scarification can be performed to create conditions conducive to germination of species other than

sugar maple, without deviating from the core guidelines of single tree selection. Many of these activities are being used in NH-SEED on the Ford Forest (Hupperts et al., 2018).

It is well documented that FFOs rate scenic beauty and protection of nature and biodiversity as important reasons for owning forestland (Brush, 1979; Butler, Hewes, et al., 2016; Rouleau et al., 2016). Single tree selection is likely the preferred method amongst FFOs in this study (87% were familiar with it and 53% had previously implemented the method, and 62% reported it to be the method they were most likely to implement) possibly because they believe it achieves those objectives, among others. However, the literature has shown that single tree selection is contributing to the homogenization of northern hardwood forests (Hupperts et al., 2018; Neuendorff et al., 2007; Schwartz et al., 2005). Therefore, this method may not meet those objectives (biological diversity and hunting) prioritized by landowners and the case can be made that other methods should be pursued for implementation on family forestland.

5.4 A note on theory

Both theories discussed in the literature review provide some insight into the reported attitudes and behaviors of FFOs who participated in this study. The survey booklet landowners received contained information that was both broad and concise. This makes the rational choice theory a useful framework because the utility of each method was touched upon in various ways. Respondents who valued wildlife habitat could use the information provided to decide which treatment maximized their goals for their forestland. This is shown clearly by the preference for clearcut by those who hunt, or the strong preference for single tree selection by those who value harvesting timber. However, given the limited information provided in the questionnaire, landowners may be indicating preferences and attitudes with imperfect or incomplete knowledge, which complicates the usefulness of rational choice theory

The theory of planned behavior is similarly limited in its ability to frame the outcomes of this study, though certain elements of the theory are applicable. This theory posits that the ability to control one's decision is an important driver of behavior. In that sense, the photos and descriptions provided in the survey instrument allowed the

respondent to anticipate what each treatment might look like on their forestland. Behavioral control may also be driving the finding that previous positive experiences with shelterwood and single tree selection were strong positive predictors for likely future use of those methods. Thus, landowners who were familiar with the outcome of each method and satisfied with the result, and more likely to engage in the behavior again. Lacking from this study, however, was any sort of strong measurement of social norms among the respondents, which makes it difficult to refute or support to the validity of the planned behavior theory within the context of the results of this study.

6. Conclusion

Silviculture is a complex discipline that continues to evolve although many of the core tenets have and will continue to persist. Managers must continually educate themselves as the discipline grows and changes to keep up with the best and latest science. Therefore, it is hardly reasonable to expect FFOs to be informed on what silvicultural knowledge is relevant to them and their forestland. Respondents to this survey clearly demonstrated that a basic level of knowledge exists among the FFOs in the WUP. Unsurprisingly, the basics of the clearcut method were familiar, whereas shelterwood, a method less frequently used in the region, appeared to be only familiar to those who had implemented it. It is also relatively clear what specific silvicultural methods among the three in this study are preferred by FFOs and why. Although clearcut was unfavored by most, respondents who owned land for hunting and timber appeared to acknowledge its utility. Single tree selection was favored by those who likely had a stronger interest in forest management. Much like the managers who seek to help them, respondents appeared to be fitting silvicultural methods to their management goals.

The premise for this study hinges on the concern that the use of single tree selection as the predominant management mechanism of the northern hardwood forest is producing conditions that are less than desirable. This concern was not mentioned or discussed in the questionnaire booklet that landowners received. Therefore, it is difficult to determine how FFOs will respond if provided knowledge regarding the potential for single-tree selection to reduce species diversity and resilience throughout the region.

Furthermore, it may be difficult to determine any changes in management once they do occur, since tracking FFO timber harvests is possible only for those ownerships enrolled in voluntary tax incentive programs or using remote sensing techniques. Remote sensing methods may be the most reliable and promising means to track timber harvests over time, as demonstrated by a 2018 study that used LandSat imagery to track changes in forest cover on FFO parcels (Tortini, Mayer, Hermosilla, Coops, & Wulder, 2018)

FFOs who ranked timber as an important reason for owning forestland, through the results of this survey and anecdotal evidence, appear to be entrenched with single tree selection as their method of choice, even though this method may not be best achieving their preferences. Convincing those stakeholders to consider other management options such as clearcuts, shelterwoods, or a different silvicultural method, may be challenging. Forestry outreach materials and extension services traditionally focus on the transfer-of-knowledge from a forestry professional to a forest landowner. As mentioned previously, the nature of silvicultural practices can make it challenging for landowners to retain information, let alone exhibit a behavioral change. Pamphlets and lectures may not be the most effective means to share and encourage silviculture, or forest management as a whole (Ma, Kittredge, & Catanzaro, 2012).

Instead, those (e.g. forestry professionals, extension agents, academics) concerned with the silviculture status quo, or lack thereof, on family forestland may be better off targeting FFOs who have already performed some sort of management on their land. These landowners are typically active managers of their forestland, and they may own larger parcels and have an extended tenure. Targeted efforts at demonstrating why silviculture is important and the various methods that landowners might consider could be crucial in helping prevent the proliferation of maplelization as well as creating more climate resilient forests. Future research efforts could focus on these active landowners and dig deeper into silviculture by ground truthing results of a survey-based study. Workshops, focus groups, and extended interviews all specifically focusing on silvicultural methods could provide a deeper insight into what methods FFOs are interested in adopting. In addition to formal efforts by a knowledge source, peer to peer

networks can also be an effective way of disseminating information (Kueper, Sagor, & Becker, 2013; Lind-Riehl et al., 2015; Ma et al., 2012; Schubert & Mayer, 2012). The main challenge with relying on peer networks is the strong preference of single tree selection by current FFOs. In order for there to be a broader conversation on silviculture amongst FFOs, some landowners must have positive experiences with different methods in their northern hardwood forests. In this regard, consulting foresters might consider broadening the silvicultural tools commonly used to manage northern hardwoods owned by FFOs.

Other ways of reaching landowners who might be open to various kinds of management would likely involve focusing on hunting. This study demonstrated that landowners who own their land for hunting were more open to the clearcut and shelterwood than the rest of the sample, with exception of FFOs who rank timber as an important reason for owning forestland. Active hunters are relatively easy to reach since they often aggregate in groups, such as sportsmen's clubs and organizations like Whitetails Unlimited or the Ruffed Grouse Society. Hunters also are required to obtain licenses from the state in order to hunt. Finally, hunters who own forestland regularly attend workshops on topics such as quality deer management or food lot creation, which are often provided by the Michigan Department of Natural Resources and other conservation organizations. These attributes make hunters an easy group to target for both research and active outreach regarding silviculture. Again, if more intensive methods prove to be a better means of introducing biodiversity into maplelized forests, FFOs who value hunting may be more likely to integrate these methods in their forest.

Changes in management also need to be considered at the landscape scale. Groups such as the Northern Institute of Applied Climate Science (NIACS 2019) have created frameworks and resources that aim to help managers and landowners with forest management concerns related to climate change across the Lake States. These efforts include assisted species migration, implementation of alternative silvicultural methods, and carbon inventories. Researchers in the Applied Forestry and Wildlife Ecology Laboratory at Michigan State University are currently working with the Michigan

Department of Natural Resources to implement and monitor various 30 acre seed tree, shelterwood, clearcut, and single tree selection replications in northern hardwood forests across the state (Roloff, 2017). Aimed at creating greater species diversity in the forest overstory in the face of deer herbivory, this study shares many qualities with NH-SEED. As with all long-term forestry efforts, these applications will only be fully understood in time, but they are important contributions to broadening the scope of northern hardwood management across the boundaries of ownership.

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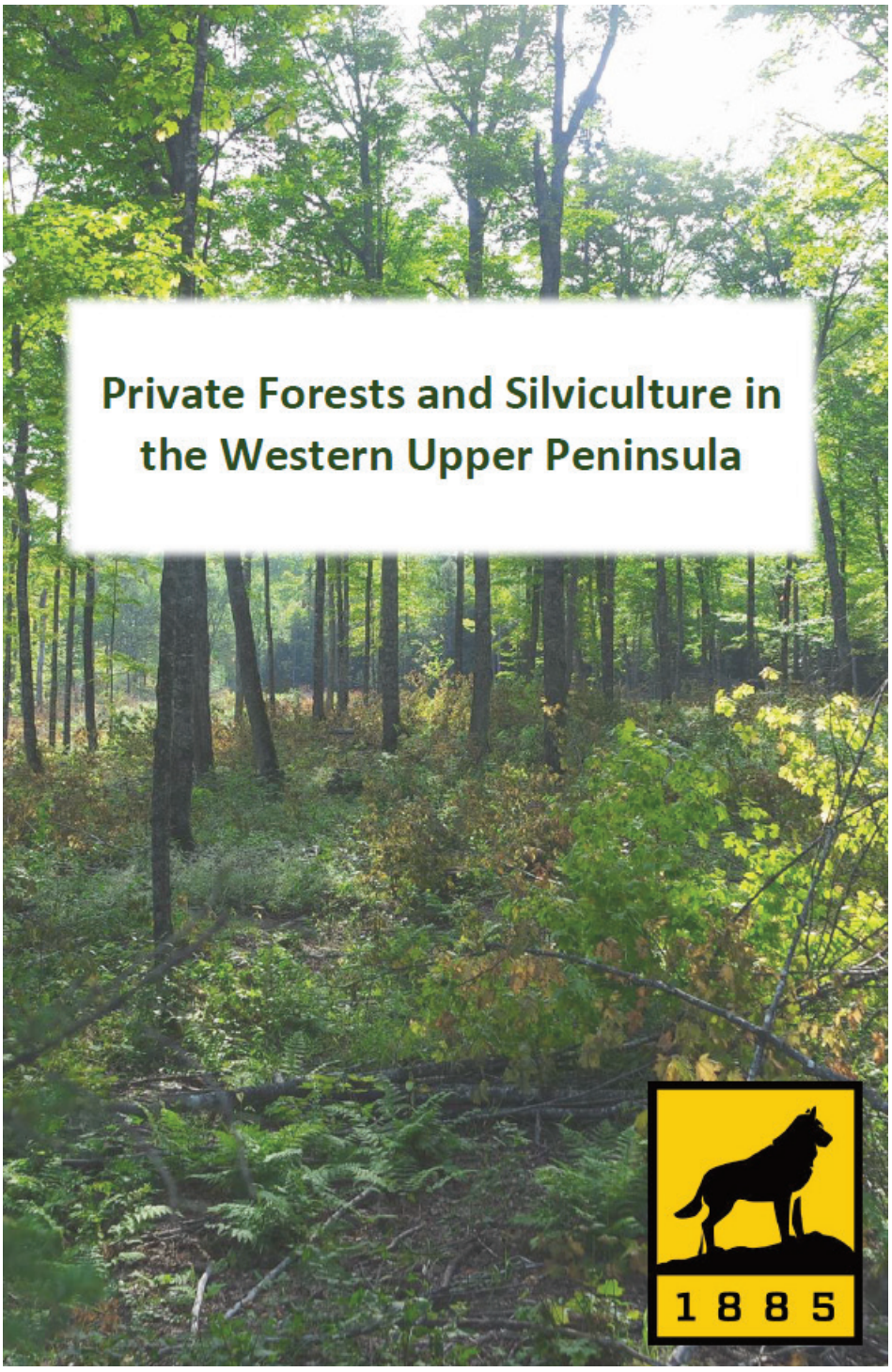
Appendix A: Questionnaire

The following document is the same questionnaire that was sent to family forest owners in the Western Upper Peninsula of Michigan. This questionnaire received proper IRB approval for use with survey participants.


Private Forests and Silviculture in the Western Upper Peninsula
1885

Dear Landowner,

Michigan Technological University

You have been randomly selected to participate in a research study. The purpose of this study is to better understand forest owners' preferences for various methods for growing and harvesting trees on their forest property. We would greatly appreciate you taking the time to complete this survey. The results of this study are expected to inform policies and programs that promote sustainable forest management on privately owned forests. This study is funded by the US Department of Agriculture and Michigan Tech.

Your participation is completely voluntary and there is no penalty for not participating. If you choose to participate, please complete and return this survey using the enclosed postage-paid envelope. You will be asked questions about your forestland, your past management activities, and your perceptions of different timber harvesting methods. You may answer as many or as few questions as you feel comfortable answering. Your responses will remain strictly confidential and will not be identified with you personally. This survey should take about 10 to 15 minutes to complete. Please use the business return envelope to return your responses to us in one to two weeks time.

If your property has multiple owners, please have the person responsible for forest management decisions complete the survey. Also, if you own multiple properties in the UP, please answer the questions with all of your properties in mind.

If you have any questions or concerns about completing the survey or about participating in this study, please do not hesitate to contact us. If you have any questions about your rights as a research subject, you may contact the Office of Compliance, Integrity, and Safety.

Thank you for your time!

Sincerely,

Matt Kelly, Ph.D.
Assistant Professor
(906)487-3403
mackelly@mtu.edu

Alex Helman
Graduate Student (MS)
(906)370-7151
achelman@mtu.edu

School of Forest Resources and Environmental Science
Michigan Technological University

Office of Compliance, Integrity, and Safety
1400 Townsend Drive
302 Lakeshore Center
Houghton, MI 49931
(906) 487-2902

SECTION 1: General questions about your forested land in the U.P.

1. How many acres of forested land do you own in the Western UP?

   _____ acres

2. Approximately what percent of your forested land is deciduous (hardwood) tree species and what percent is coniferous (evergreen) tree species?

   ____ % deciduous ____ % coniferous

3. How many years have you owned your forested land? _____ years

4. How did you acquire your forested land?

   ☐ Purchased ☐ Inherited ☐ Both

5. Is your primary residence on your forested land?

   ☐ Yes ☐ No → *Skip to Question 8*

6. How many miles is your primary residence away from your forested land?

   ____ miles

7. How would you describe the location of your permanent residence?

   ☐ Urban ☐ Suburban ☐ Rural

8. Do you currently have or have you ever had a forest management plan that was written by a professional forester?

   ☐ Yes ☐ No

9. Have you performed active forest management on your property? (This includes cutting trees for firewood, for recreation, for a commercial timber harvest, for wildlife habitat, and/or for scenery)

   ☐ Yes ☐ No → *Skip to Question 11*

10. If so, what was the main purpose?

    ☐ Firewood ☐ Commercial timber harvest

    ☐ Recreation ☐ Wildlife habit improvement

    ☐ Scenery ☐ Invasive species removal

    ☐ Other (Please specify _____)

Section 1 continued

11. How important are the following reasons for why you currently own forestland in the UP?

Reason for owning forestland	Not important	Slightly important	Moderately important	Important	Very important
To enjoy beauty or scenery	☐	☐	☐	☐	☐
To protect nature or biological diversity	☐	☐	☐	☐	☐
For land investment	☐	☐	☐	☐	☐
For privacy	☐	☐	☐	☐	☐
To raise my family	☐	☐	☐	☐	☐
To pass land on to my children or other heirs	☐	☐	☐	☐	☐
For firewood	☐	☐	☐	☐	☐
For timber products, such as logs or pulpwood	☐	☐	☐	☐	☐
For nontimber forest products, such as berries or maple syrup	☐	☐	☐	☐	☐
For hunting	☐	☐	☐	☐	☐
For recreation other than hunting	☐	☐	☐	☐	☐
Other, please specify:	☐	☐	☐	☐	☐

Section 1 continued

12. Several **management plan assistance programs** exist to help landowners with the cost of creating a forest management plan. Have you ever participated in the following programs?

    ☐ Natural Resource Conservation Service CAP 106

    ☐ Forest Stewardship Program

    ☐ Other (Please specify: _____)

    ☐ I have not participated in any management plan assistance program

13. Is any of your forested land currently enrolled in any of the following **tax reduction programs**?

    ☐ Commercial Forest Program (Michigan DNR)

    ☐ Qualified Forest Program (Michigan DARD)

    ☐ Conservation easement

    ☐ Other (Please specify: _____)

    ☐ My land is not currently enrolled in a tax program

14. Is any of your forested land currently enrolled in any of the following **forest certification systems**?

    ☐ American Tree Farm System

    ☐ Sustainable Forestry Initiative

    ☐ Forest Stewardship Council

    ☐ Other (Please specify: _____)

    ☐ My land is not currently enrolled in a certification system

Section 2 – What is *Silviculture*?

Just as horticulture is the practice of growing a garden, and agriculture is the practice of growing crops for food, **silviculture** refers to the art and science of growing and managing forests sustainably.

Silvicultural methods differ from practices that exploit the forest for immediate gain but have no concern for the future health and value of the forest. For example, "high-grading" refers to the practice of removing only the valuable trees while leaving only unhealthy and low-value trees left to grow. In contrast, harvesting trees using silvicultural methods can provide immediate benefits while ensuring the future growth and development of high quality forests.

The following section highlights three silvicultural methods that may be used to manage northern hardwood forests. For each method you will be asked to review some quick facts about the method and an image from a recent harvest at the Michigan Tech Ford Forest in Alberta, MI. Please review the image and facts about each method and then answer the questions on the opposite page. The questions will be about your experiences and perceptions of the method described.

Michigan Tech
School of Forest Resources
and Environmental Science

Silviculture Questions

15. How familiar are you with the term "**clearcut**"?

- ☐ Not at all familiar
- ☐ Slightly familiar
- ☐ Somewhat familiar
- ☐ Moderately familiar
- ☐ Extremely familiar

16. How familiar are you with the term "**single tree selection**"?

- ☐ Not at all familiar
- ☐ Slightly familiar
- ☐ Somewhat familiar
- ☐ Moderately familiar
- ☐ Extremely familiar

17. How familiar are you with the term "**shelterwood**"?

- ☐ Not at all familiar
- ☐ Slightly familiar
- ☐ Somewhat familiar
- ☐ Moderately familiar
- ☐ Extremely familiar

For the following section, please answer all questions with only the portions of your forested land that are **northern hardwood** in mind. These forests are typically comprised of **hardwood tree species** such as **maples, oaks, ashes, elms, birches, and basswood,** and may include scattered **conifer tree species** such as **white pine, balsam fir, spruces, and hemlock.**

Clearcut Method

The above photo shows a northern hardwood stand following a clearcut harvest. The size of this particular clearcut is about 6 acres.

- Removes: All trees are cut in a single harvest within a relatively large area (greater than 3 acres). Only small seedlings are left and some standing dead trees for wildlife.

- Next commercial harvest: About 50 years after the initial harvest, the new stand will be ready for a commercial thinning. Thinnings can occur every 10 to 15 years until around 85 to 100 years, when the stand is ready to be regenerated using clearcut or shelterwood method.

- Tree species favored: Will regenerate sugar and red maple, white ash and yellow birch, but may favor species that prefer full light, such as black cherry and white birch.

- Wildlife species favored: Ruffed grouse, American woodcock, northern flicker, red-eyed vireo, Swainson's thrush, martens, foxes, and wood frogs.

Clearcut Questions

18. Have you ever harvested trees using a **clearcut** in your northern hardwood forest?

☐ Yes ☐ No ☐ I don't know *Skip to Question 20*

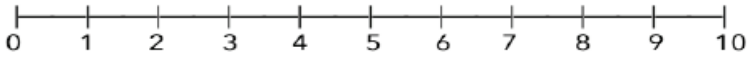
19. If **yes** to Question 18, how satisfied were you with the results of the harvest?

☐ Very Dissatisfied
☐ Dissatisfied
☐ Unsure
☐ Satisfied
☐ Very Satisfied

20. Would you consider harvesting trees using a **clearcut** within the next 10 years?

☐ Yes ☐ No

21. Place an X on the line below to indicate the likelihood you would harvest trees using a **clearcut** in the next 10 years. (0 being extremely unlikely, 10 being extremely likely)



22. How important are the following factors in your decision as to why you would or why you would not harvest trees using a **clearcut?**

Factors	Not important	Slightly important	Moderately important	Important	Very important
Financial (ability to generate revenue)	☐	☐	☐	☐	☐
Effects on wildlife habitat	☐	☐	☐	☐	☐
Effects on recreation	☐	☐	☐	☐	☐
Effects on scenic beauty/aesthetics	☐	☐	☐	☐	☐
Other, please specify:	☐	☐	☐	☐	☐

Shelterwood Method

The above photo shows a northern hardwood stand after a shelterwood harvest. Notice only large trees are left at relatively wide spacing.

- Removes: Most trees, but leaves scattered large trees of good form to act as a seed source and to protect young seedlings.
- Next Commercial Harvest: 5 – 10 years after initial harvest the remaining large trees can be removed. At 50 years after the initial harvest, the regrown forest can be commercially thinned. Thinnings can occur every 10 to 15 years until around 85 to 100 years, when the stand is ready to be regenerated using clearcut or shelterwood method.
- Tree Species Favored: Will regenerate sugar and red maple, but may favor species that prefer limited shade, such as red and white oak, black and white ash, white pine, and yellow birch.
- Wildlife Species Favored: Will create habitat suitable for broad-winged hawks, ruffed grouse, wood duck, white-tailed deer, martens and fishers.

Shelterwood Questions

23. Have you ever harvested trees using a **shelterwood** in your northern hardwood forest?

☐ Yes ☐ No ☐ I don't know → *Skip to Question 25*

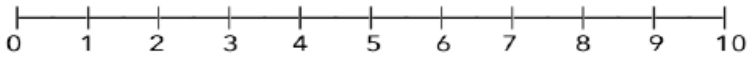
24. If **yes** to Question 23, how satisfied were you with the results of the harvest?

☐ Very Dissatisfied
☐ Dissatisfied
☐ Unsure
☐ Satisfied
☐ Very Satisfied

25. Would you consider harvesting trees using a **shelterwood** within the next 10 years?

☐ Yes ☐ No

26. Place an X on the line below to indicate the likelihood that you would harvest trees using a **shelterwood** in the next 10 years. (0 being extremely unlikely, 10 being extremely likely)



27. How important are the following factors in your decision as to why you would or why you would not harvest trees using a **shelterwood?**

Factors	Not important	Slightly important	Moderately important	Important	Very important
Financial (ability to generate revenue)	☐	☐	☐	☐	☐
Effects on wildlife habitat	☐	☐	☐	☐	☐
Effects on recreation	☐	☐	☐	☐	☐
Effects on scenic beauty/aesthetics	☐	☐	☐	☐	☐
Other, please specify:	☐	☐	☐	☐	☐

Single Tree Selection

The above photo shows a northern hardwood stand after a single-tree selection harvest. Notice the range in tree sizes.

- Removes: Large trees, unhealthy trees, and some pole-sized trees, are removed, creating small gaps in the forest. But many trees of a range of sizes are left behind.
- Next commercial harvest: The stand can be harvested roughly every 15 years. Each harvest will result in relatively consistent harvest volumes and post-harvest conditions.
- Tree species favored: Shade tolerant species such as sugar maple, red maple, basswood, hemlock and balsam fir.
- Wildlife species favored: White-tailed deer, black bear, many species of woodpecker, crossbills, scarlet tanagers, barred and saw-whet owls, snowshoe hares, and weasels.

Single Tree Selection Questions

28. Have you ever harvested trees using **single tree selection** in your northern hardwood forest?

☐ Yes ☐ No ☐ I don't know → *Skip to Question 30*

29. If **yes** to Question 28, how satisfied were you with the results of the harvest?

☐ Very Dissatisfied
☐ Dissatisfied
☐ Unsure
☐ Satisfied
☐ Very Satisfied

30. Would you consider harvesting trees using **single tree selection** within the next 10 years?

☐ Yes ☐ No

31. Place an X on the line below to indicate the likelihood that you would harvest trees using **single tree selection** in the next 10 years. (0 being extremely unlikely, 10 being extremely likely).

0 1 2 3 4 5 6 7 8 9 10

32. How important are the following factors in your decision as to why you would or would not harvest trees using **single tree selection**?

Factors	Not important	Slightly important	Moderately important	Important	Very important
Financial (ability to generate revenue)	☐	☐	☐	☐	☐
Effects on wildlife habitat	☐	☐	☐	☐	☐
Effects on recreation	☐	☐	☐	☐	☐
Effects on scenic beauty/aesthetics	☐	☐	☐	☐	☐
Other, please specify:	☐	☐	☐	☐	☐

33. Which of the silviculture methods covered in this booklet, if any, are you most likely to use to manage your northern hardwood forest? (Select only one)
    - ☐ Clearcut
    - ☐ Single tree selection
    - ☐ Shelterwood
    - ☐ None

SECTION 3: Questions about you.

34. What is your age? _____

35. What is your gender? _____

36. What is your highest level of education?
    - ☐ Less than 12th grade
    - ☐ High school/diploma
    - ☐ Some college
    - ☐ Associate degree
    - ☐ Bachelor's degree
    - ☐ Advanced degree

37. What is your annual household income?
    - ☐ Less than $25,000
    - ☐ $25,000 to $49,999
    - ☐ $50,000 to $99,999
    - ☐ $100,000 to $199,999
    - ☐ $200,000 or more

38. On average, what percentage of your household's annual income comes from the forested land that you own?

    _____%

39. Would you be interested in participating in a forest ecology and management workshop at Michigan Tech's Ford Forest in Alberta, MI?
    - ☐ Yes ☐ No